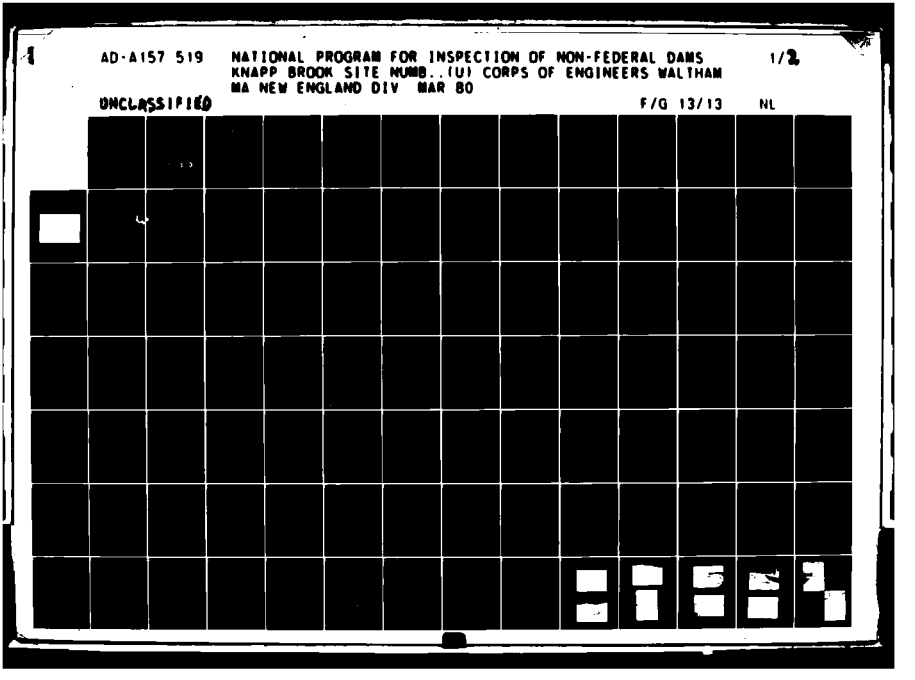
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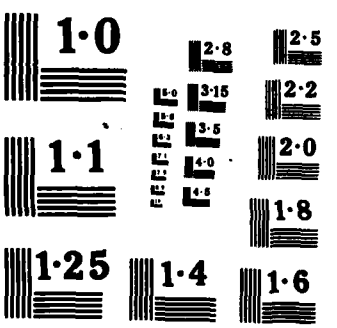
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CONNECTICUT RIVER BASIN
CAVENDISH, VERMONT

KNAPP BROOK SITE NO. 2
VT. 00077

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS. 02154

MARCH 1980

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER VT 00077	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Knapp Brook Site No. 2 NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS		5. TYPE OF REPORT & PERIOD COVERED INSPECTION REPORT 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) U.S. ARMY CORPS OF ENGINEERS NEW ENGLAND DIVISION		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS DEPT. OF THE ARMY, CORPS OF ENGINEERS NEW ENGLAND DIVISION, NEDED 424 TRAPELO ROAD, WALTHAM, MA. 02254		12. REPORT DATE March 1980 13. NUMBER OF PAGES 45
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

APPROVAL FOR PUBLIC RELEASE: DISTRIBUTION UNLIMITED

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Cover program reads: Phase I Inspection Report, National Dam Inspection Program; however, the official title of the program is: National Program for Inspection of Non-Federal Dams; use cover date for date of report.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

DAMS, INSPECTION, DAM SAFETY,
Connecticut RVver Basin
Cavendish, VT.
Knapp Brook

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

TCe dam is an earth embankment with clay core. ~~The dam is~~ about 540 ft. long and 27 ft.high. THe dam is small in size with a significant hazard potential. TTe test flood is ½ the PMF. The dam is judged to be in fair condition although there were a few concerns noted. There are various recommendations which should be undertaken by the owner.

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DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02154

REPLY TO
ATTENTION OF:
NEDED

JUN 19 1980

Honorable Richard A. Snelling
Governor of the State of Vermont
State Capitol
Montpelier, Vermont 05602

Dear Governor Snelling:

Inclosed is a copy of the Knapp Brook Site No. 2 Phase I Inspection Report, which was prepared under the National Program for Inspection of Non-Federal Dams. This report is presented for your use and is based upon a visual inspection, a review of the past performance and a brief hydrological study of the dam. A brief assessment is included at the beginning of the report. I have approved the report and support the findings and recommendations described in Section 7 and ask that you keep me informed of the actions taken to implement them. This follow-up action is a vitally important part of this program.

A copy of this report has been forwarded to the Department of Water Resources, the cooperating agency for the State of Vermont. In addition, a copy of the report has also been furnished the owner, State of Vermont, Fish & Game Department, Montpelier, Vermont 05602.

Copies of this report will be made available to the public, upon request, by this office under the Freedom of Information Act. In the case of this report the release date will be thirty days from the date of this letter.

I wish to take this opportunity to thank you and the Department of Water Resources for your cooperation in carrying out this program.

Sincerely,

MAX B. SCHEIDER
Colonel, Corps of Engineers
Division Engineer

Incl
As stated

KNAPP BROOK SITE NO. 2

VT00077

CAVENDISH, VERMONT

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

NATIONAL DAM INSPECTION PROGRAM
PHASE I INSPECTION REPORT

Identification No:	VT00077
Name of Dam:	Knapp Brook Site No. 2
Town:	Cavendish
County and State:	Windsor County, Vermont
Stream:	Knapp Brook
Date of Inspection:	April 23, 1979 and May 22, 1979

BRIEF ASSESSMENT

The Knapp Brook Site No. 2 Dam is an earth embankment with clay core. The dam is approximately 540 feet long and 27 feet high. The dam and pond are currently utilized as a State of Vermont Fish and Game pond. A semicircular spillway structure containing a 4-foot by 2-foot sluice gate is the primary control of flow at the dam. This structure handles both seasonal and flood flows while an outlet structure with stop logs controls daily runoff. The drainage area for this dam is 2.9 square miles and under normal conditions has an impoundment of 368 acre-feet with a surface area of 36 acres.

The dam is classifetd as small and has a significant hazard potential. Based on size and hazard classifications, a one-half Probable Maximum Flood (1/2 PMF) of 45 CFS was used as the test flood. The routed test flood outflow was 4,360 CFS. The total spillway capacity is 7150 CFS which is 164 percent of the test flood outflow. The test flood would be 1.4 feet below the crest of the dam.

The dam is judged to be in fair condition. The following significant findings were determined during the investigation:

1. The lowermost retaining wall of the spillway chute is experiencing lateral movement due to frost action.

2. The routed test flood outflow exceeds the concrete spillway capacity. The old earth spillway channel could erode and undermine the new concrete discharge channel should floods equivalent to the test flood occur.

It is recommended that the following actions be instituted under the guidance of a registered professional engineer qualified in dam design within one year of receipt of this report:

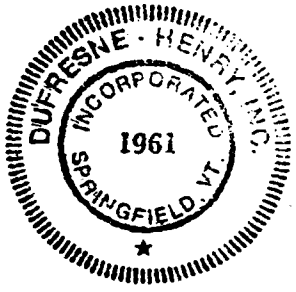
1. The displacement of the retaining walls of the spillway channel should be evaluated.

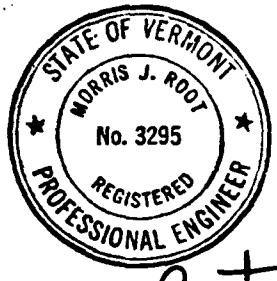
2. The concrete channel spillway should be evaluated with regard to the need for greater flood capacity.

3. Institute a biennial program of technical inspections to include monitoring of the wet areas on the right stream bank immediately downstream of the outlet structure for flow volume and evidences of soil transport.

4. Provide round-the-clock monitoring during periods of unusually heavy rainfall or high project discharge.

5. Prepare a formal warning plan.





Morris J. Root

This Phase I Inspection Report on Knapp Brook Site No. 2 has been reviewed by the undersigned Review Board members. In our opinion, the reported findings, conclusions, and recommendations are consistent with the Recommended Guidelines for Safety Inspection of Dams, and with good engineering judgement and practice, and is hereby submitted for approval.

Joseph W. Finegan

JOSEPH W. FINEGAN, JR., MEMBER
Water Control Branch
Engineering Division

Carney M. Terzian

CARNEY M. TERZIAN, MEMBER
Design Branch
Engineering Division

Joseph A. McElroy

JOSEPH A. MCELROY, CHAIRMAN
Chief, NED Materials Testing Lab.
Foundations & Materials Branch
Engineering Division

APPROVAL RECOMMENDED:

Joe B. Fryar

JOE B. FRYAR
Chief, Engineering Division

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing and detailed computational evaluations are beyond the scope of a Phase I Investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test Flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

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APPENDICES

SECTION 3 - VISUAL INSPECTION

3.1 Findings

a. General

The dam was inspected on April 23, 1979 when the water level was 2.3 feet below the crest of the spillway weir and about 8 feet below the crest of the dam. Water was flowing through the gate located to the right of the spillway and into the spillway channel. There was still snow on part of the downstream slope and thus the downstream slope was reinspected on May 22, 1979. On May 22 the water level in the reservoir was several inches below the spillway weir crest.

b. Dam

The dam is an earth embankment with a concrete intake structure and an outlet pipe through the dam and a concrete spillway in the left abutment.

The upstream slope of the dam is covered with riprap to within an elevation of about 4 feet below the crest. The upper part of the slope is grass covered (see Photo 3). The riprap is in good condition with some displaced riprap in a few small areas (see Photo 4). The crest of the dam is covered with gravel and is apparently used as a service road. There is no significant erosion on the crest. The downstream slope is grass covered and shows no sign of erosion or sloughing (see Photo 8). There were no wet areas observed on the slope. At the lowest point of the toe there is riprap protection for the slope because of tailwater from Knapp Brook Pond No. 1.

c. Appurtenant Structures

The inlet structure is connected by a wooden bridge to the crest of the dam. One of the posts supporting the bridge is broken as a result of ice pressure (see Photos 2 and 11). The concrete outlet structure is in good condition (see Photo 12). Immediately downstream of the outlet structure and along the banks of the old stream bed there is some erosion and apparent seepage near the dam (see Photo 13).

The concrete spillway at the left abutment is generally in good condition. The spillway weir is in plan a half circle and there is also a gated outlet at the right end of the weir as shown in Photo 5. There is some inward movement of the retaining walls of the discharge channel which has resulted.

SECTION 2 - ENGINEERING DATA

2.1 Design Data

The plans describing the design of this earth embankment dam, outlet works and emergency spillways are contained in Appendix B of this report.

2.2 Construction Data

The present dam is a 540-foot earth embankment with a clay core and impervious zones on the up and downstream side of the core which is 540 feet long overall with about 100 feet of the left abutment occupied by the emergency spillways. It was designed by the firm of Haley and Ward Engineers in 1960 and was constructed by the State of Vermont Fish and Game Commission in 1962. The spillway was redesigned by Dufresne-Henry Engineering Corporation in 1973 and construction was completed in the spring of 1974.

2.3 Operation Data

Both Knapp Brook Pond Sites No. 1 and No. 2 are operated by the State of Vermont Fish and Game Department and are used as fishing ponds. According to Fish and Game personnel, Knapp Brook Site No. 2 Dam is operated on a seasonal basis. The 4-foot by 2-foot sluice gate is opened in late fall and left open until spring runoff has taken place. After the spring runoff this sluice gate is closed and the water level is then maintained at the top of the semicircular weir. The other sluice gate at the outlet works is not normally used, but the stop logs are being used to control pond temperatures.

2.4 Evaluation

a. Availability

The design plans for this dam are on file with the Agency of Environmental Conservation, Department of Water Resources, Montpelier, Vermont 05602.

b. Adequacy

The lack of in-depth engineering data does not allow for an in-depth analysis of the dam. Therefore, the adequacy of the dam must be based on visual inspection, past performance history and sound hydrologic and hydraulic engineering judgment.

c. Validity

Not applicable.

(5) Upstream Channel

The upstream channel is a 60-foot wide excavated channel 30 feet long. Included is a 6-foot, 3-inch wide concrete box approach channel which is 25 feet long.

(6) Downstream Channel

Knapp Pond No. 1.

j. Regulating Outlets

Both the wall on the semicircular weir and outlet structure have sluice gates. The approach channel to the sluice gate of the semicircular weir also contains a bar screen on the upstream end. The outlet structure also has one set of stop logs in series in addition to a 2-foot by 2-foot sluice gate with an invert elevation of 93.5.

(5) Side Slopes

Downstream slope - 1:3
Upstream slope - 1:3

(6) Zoning

Central clay core, upstream impervious fill, downstream impervious fill with pervious shell.

(7) Impervious Core

6-foot thick clay core to elevation 110.0.

(8) Cut-off

Clay core extends 3 feet into old channel cross section and old concrete cut-off wall is extended down 4 feet below old spillway crest.

(9) Grout Curtain

None known.

h. Diversion and Regulating Tunnel

Not applicable.

i. Spillway

(1) Type

New - semicircular weir with concrete chute.
Old - earth cut with concrete weir.

(2) Length

New - 62.8-foot crest of semicircular weir.
Old - 57-foot crest.

(3) Elevation of Crest

107.0 feet, semicircular weir.
109.0 feet, old weir.

(4) Gates

4-foot by 2-foot at invert elevation of 103 in right side of semicircular weir.

(3) Spillway Crest Pool

368 acre-feet.

(4) Top of Dam

623 acre-feet.

f. Reservoir Surface

(1) Recreation Pool

30 acres - winter and spring (elevation 103).
36.5 acres - summer and fall (elevation 107).

(2) Flood Control Pool

Not applicable.

(3) Spillway Crest

36.5 acres.

(4) Test Flood Pool

42.0± acres.

(5) Top of Dam

44.0± acres.

g. Dam

(1) Type

Compacted earth embankment with clay core.

(2) Length

540 feet.

(3) Height

27.3± feet above streambed.
21.7± feet above Knapp Pond #1 normal water surface.

(4) Top Width

20 to 24 feet.

(4) Recreation Pool

107.0 - gate closed, summer and fall.

103.0± - gate open, winter and early spring.

(5) Full Flood Control Pool

Not applicable.

(6) Spillway Crest

107.0 - new spillway; 109.0 - old weir.

(7) Design Surcharge

Not applicable.

(8) Top of Dam

113.3±.

(9) Test Flood Surcharge

111.8

d. Reservoir

(1) Length of Maximum Pool

3,400 feet.

(2) Length of Recreation Pool

3,300 feet.

(3) Length of Flood Control Pool

Not applicable.

e. Storage

(1) Recreation Pool

233 acre-feet - winter and spring (elevation 103).
368 acre-feet - summer and fall (elevation 107).

(2) Flood Control Pool

Not applicable.

by 1 to 1.5 feet. Estimated discharge was approximately 720 CFS. This overflow resulted in a substantial amount of erosion in the earthen exit channel which has since been replaced by the new emergency spillway.

(3) Ungated Spillway Capacity at Top of Dam

7,150 CFS at 113.3.

(4) Ungated Spillway Capacity at Test Flood Elevation

4,360 CFS at elevation 111.8.

(5) Gated Spillway Capacity at Normal Pool Elevation

Not applicable.

(6) Gated Spillway Capacity at Test Flood Elevation

Not applicable.

(7) Total Spillway Capacity at Test Flood Elevation

4,360 CFS at elevation 111.9.
3,100 CFS - new spillway.
1,260 CFS - old weir.

(8) Total Project Discharge at Test Flood Elevation

4,360 CFS at elevation 111.8.

c. Elevations

The following elevations are based on a local datum which is tied into Knapp Brook Site No. 1 Dam drop structure. The elevation of 107.0 at the crest of the semicircular weir is the datum at Knapp Brook Site No. 2. The water surface elevation is estimated to be about 1,280 feet above MSL by use of USGS map as no precise survey exists for MSL datum.

(1) Streambed

86.0 ± base of dam.
91.0 ± outlet of discharge pipe.
91.8 ± outlet of spillway channel.

(2) Maximum Tailwater

98.0 ± estimated for PMF at Knapp Brook Site No. 1.
97.0 ± estimated for one-half PMF at Knapp Brook Site No. 1.

(3) Upstream Portal Invert Diversion Tunnel

Not applicable.

Knapp Brook Site No. 2 Dam is operated on a seasonal basis. The 4-foot x 2-foot sluice gate is opened in late fall and left open until spring runoff has taken place. After the spring runoff this sluice gate is closed and the water level is then maintained at the top of the semicircular weir. The other sluice gate at the outlet works is not normally used, but the stop logs are being used to control pond temperatures.

1.3 Pertinent Data

a. Drainage Area

The drainage area of Knapp Brook Site No. 2 is 2.89 square miles with 90 percent forest land and the remainder being pasture land. The main channel is approximately 2.6 miles long with an average stream slope of 135 feet per mile. The drainage basin is covered with 50 percent Woodstock-Colrain associated soils and 50 percent Colrain-Buckland associated soils. The upper elevations in the basin are approximately 1,800 feet MSL while the pond is at approximately 1,280 feet MSL.

b. Discharge at Dam Site

(1) Outlet Works

The outlet works at Knapp Brook Site No. 2 consist of an outlet structure with service bridge and an emergency spillway at the left abutment (see Photo 2). The 6.5 x 7 x 16.5 outlet structure is a concrete structure located 50 feet upstream of and near the center of the dam embankment. This structure has stop logs and a 2-foot by 2-foot sluice gate for controlling normal water surface. The stop logs extend from the invert of the 24-inch discharge pipe to 1.5 feet below the top of the structure (see Photo 11). The second structure is an emergency spillway consisting of a 63-foot long semicircular weir with a 4-foot by 2-foot sluice gate at the right end of the weir wall (see Photo 5). The spillway chute discharges into Knapp Brook Site No. 1 which is located at the foot of the structure (see Photo 6).

(2) Maximum Known Flood at Dam Site

There are no gauging stations or operating records for the Knapp Brook Dams, but according to Bob Horton, Fish and Game Department Maintenance Supervisor, the maximum known flood at the Knapp Brook Site No. 2 Dam was the 1973 flood. According to Dufresne-Henry engineering personnel, the water overflowed the old concrete weir

e. Ownership

The present owner of Knapp Brook Site No. 2 is:

State of Vermont
Fish and Game Department
Montpelier, Vermont 05602

Telephone: 802-828-3371

f. Operator

Mr. Bob Horton, Maintenance Supervisor
Fish and Game Department
Chittenden, Vermont 05737

Telephone: 802-773-9507

g. Purpose

The Knapp Brook Ponds 1 and 2 were constructed as part of a fish management project for southern Vermont and they are still being used for this purpose.

h. Design and Construction History

This dam was designed by Haley and Ward in 1960 and built shortly afterwards (see plans in Appendix B). The original dam included the present earth embankment with clay core and an emergency spillway consisting of a 100-foot concrete weir and an earth exit channel at the left abutment. After the July 1973 flood, Dufresne-Henry Engineering Corporation was hired to design a new emergency spillway in place of the then badly eroded exit channel and service bridge to the outlet structure. This new concrete spillway consists of a semicircular weir and tapered discharge chute into Knapp Brook Site No. 1 pond and was constructed by Lowell Engineering Corporation, Inc., Lowell, Massachusetts, and was finished in 1974.

With the exception of a new stem to the spillway sluice gate, there are no indications of repairs, patching or new construction since the structures were rebuilt in 1974.

i. Normal Operating Procedures

Both Knapp Brook Pond Sites No. 1 and No. 2 are operated by the State of Vermont Fish and Game Department and are used as fishing ponds. According to Fish and Game personnel,

b. Description of Dam and Appurtenances

The Knapp Brook Site No. 2 Dam is approximately 540 feet long and 27 feet high with a concrete outlet structure located on the upstream face of the dam and a concrete spillway in the left abutment as seen in Photo #2.

The dam is an earth embankment with a clay core. Both upstream and downstream faces are sloping 1 vertical to 2 horizontal with riprap at the normal water surface elevations (see Photos #3 and #8).

The spillway consists of a 62.8-foot long semicircular concrete weir (crest elevation 107.0) and a 57-foot broad crested weir (crest elevation 109.0) with a 4-foot by 2-foot sluice gate (invert 102.8) as seen in Photo #2. Discharge from the semicircular weir flows down a 130-foot long concrete flume with flip bucket energy dissipator. The overflow from the broad crested weir flows down the south embankment outside of the flume.

The outlet structures at Knapp Brook Site No. 2 consist of a 24-inch diameter asphalt coated corrugated galvanized metal pipe culvert (invert at 93.5) located in a concrete drop structure with a 2-foot by 2-foot sluice gate (invert 93.5) and 2 sets of 5.0-foot stop logs in series set at elevation 106.8.

c. Size Classification

The Knapp Brook Site No. 2 Dam is approximately 27 feet high (see Appendix B) and has a maximum storage of 623 acre-feet. The United States Corps of Engineers (USCE) guidelines place dams with a height between 25 and 40 feet or storage between 50 and 1000 acre-feet in the small category. Therefore, the size classification of Knapp Brook Site No. 2 is small.

d. Hazard Classification

A failure of the Knapp Brook Site No. 2 Dam would release a flood wave 8,330 CFS into the Knapp Brook Site No. 1 pond. Knapp Brook Site No. 1, an earth embankment dam, would be overtopped by 2.1 feet and discharge 5,340 CFS into the natural channel. After travelling 0.8 miles the flood wave is reduced to 5,000 CFS or 3.5 feet over the stream banks where it would just barely reach the first floor of a home. In the remaining 1.6 miles of Knapp Brook there are three more homes that would be damaged and additional lives lost before the flood wave is dissipated in the flood plain of the North Branch of the Black River. Because the flood wave would damage four homes and one small commercial structure and result in the possible loss of six lives, this hazard classification is significant.

NATIONAL DAM INSPECTION PROGRAM
PHASE I INSPECTION REPORT
NAME OF DAM: KNAPP BROOK NO. 2

SECTION 1 - PROJECT INFORMATION

1.1 General

a. Authority

Public Law 92-367, August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a National Program of Dam Inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region. Dufresne-Henry Engineering Corporation has been retained by the New England Division to inspect and report on selected dams in the State of Vermont. Authorization and notice to proceed were issued to Dufresne-Henry Engineering Corporation under a letter of November 20, 1978 from Max B. Scheider, Colonel, Corps of Engineers. Contract No. DACW33-79-C-0010 has been assigned by the Corps of Engineers for this work.

b. Purpose

(1) Perform technical inspection and evaluation of non-federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by nonfederal interests.

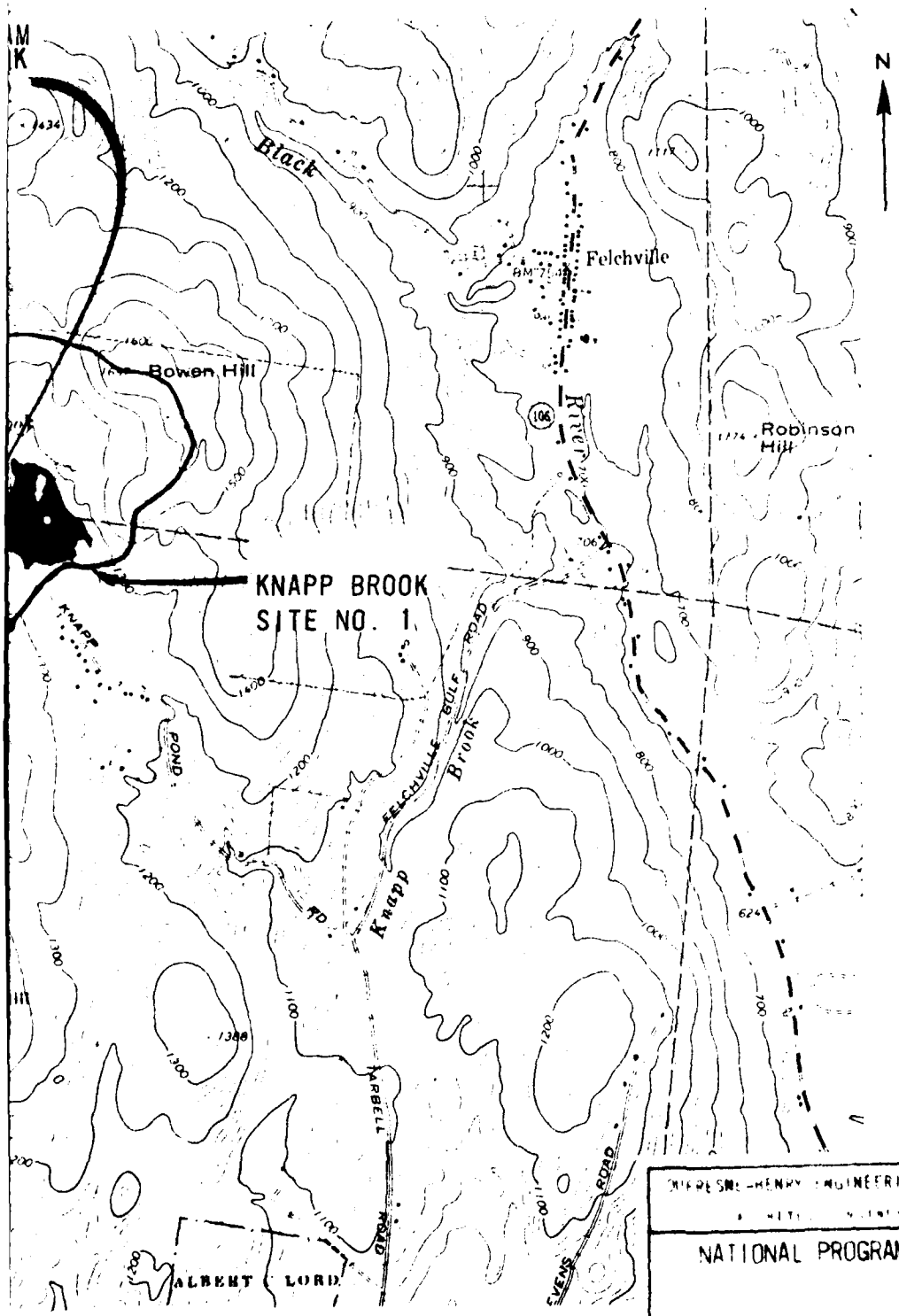
(2) Encourage and prepare the states to initiate quickly effective dam safety programs for nonfederal dams.

(3) To update, verify and complete the National Inventory of Dams.

1.2 Description of Project

a. Location

The Knapp Brook Site No. 2 Dam is one of two dams located on Knapp Brook in the Town of Cavendish, Windsor County, Vermont. The dams are located 5.0 miles north-northeast of the Village of Cavendish. Knapp Brook Site No. 2 at $43^{o}26.9'N$ $72^{o}33.5'W$ is located 1400 feet upstream of Knapp Brook Site No. 1.



SOURCE OF MAP

U S GEOLOGICAL SURVEY
CAVENDISH VERMONT
QUADRANGLE 1972
1:24000 SERIES V813

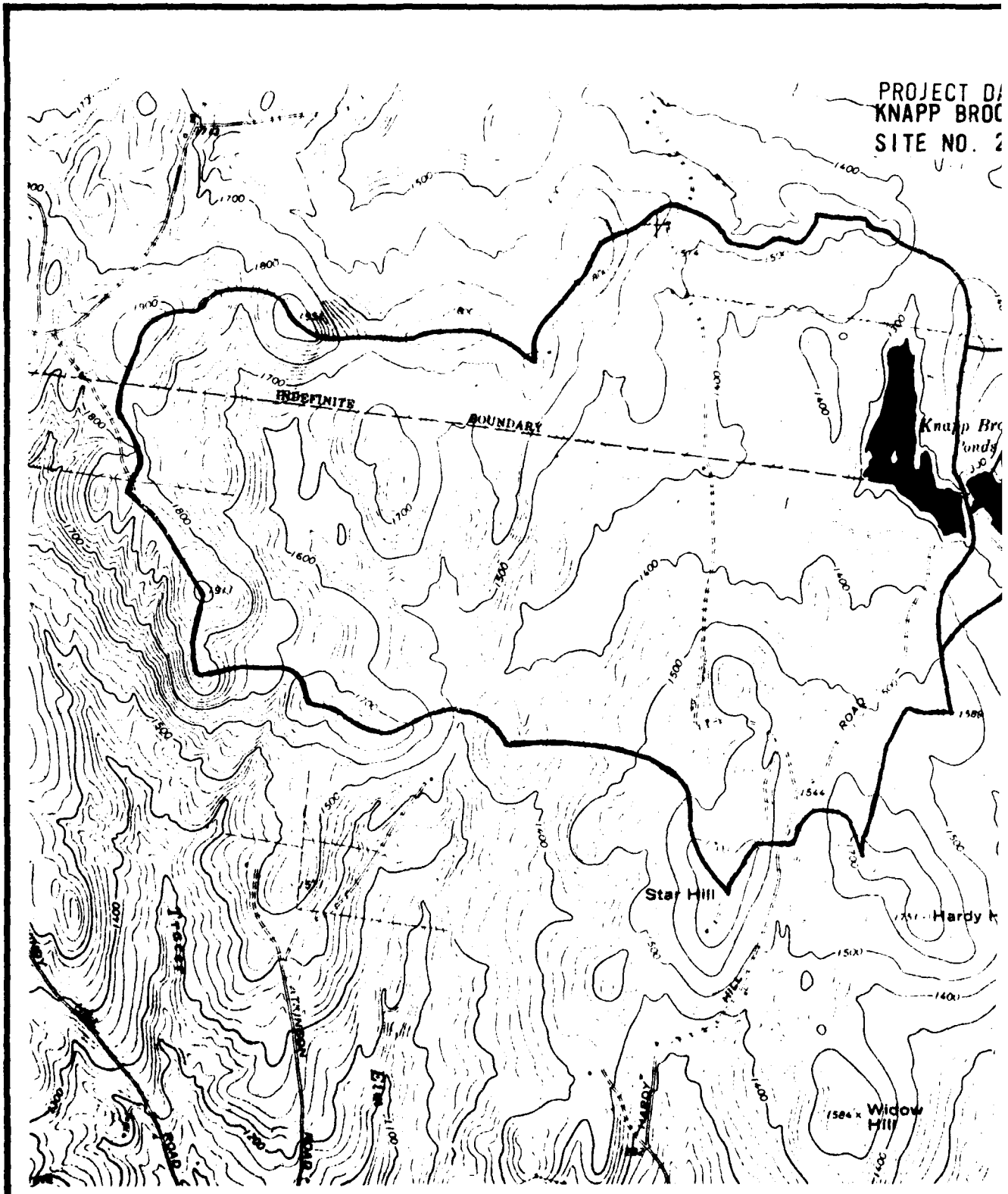
[illegible] HENRY ENGINEERING CORP.	U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

LOCATION MAP

KNAPP BROOK SITE NO. 2

CLIENT NO.	04-0091		SCALE 1"=2000'
ENGINEER	SGE		DATE


PROJECT DA
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Creek
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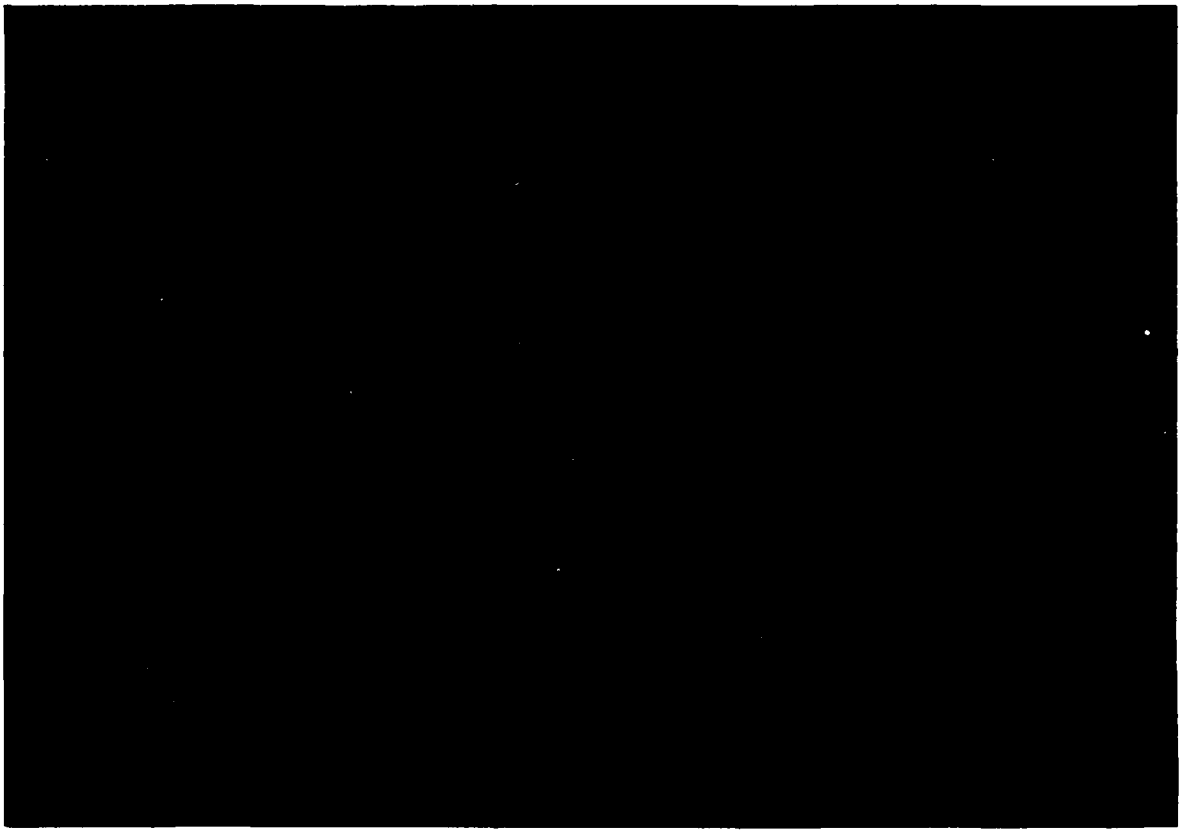


OVERVIEW OF
KNAPP BROOK SITE NO. 2
CAVENDISH, VERMONT

in some differential movements across construction joints (see Photos 9 and 10). The elevation of the upstream wing walls for the spillway is lower than the elevation of the crest of the dam. Wing walls will be overtopped before the dam is and water would flow along the outside of the discharge channel for the spillway. The area adjacent to the spillway thus becomes an emergency spillway.

d. Reservoir Area

There are no evidences of slope instability along the reservoir edge in the vicinity of the dam. Immediately to the left of the spillway the ground elevation is lower than the crest of the dam and thus the area would constitute an emergency spillway as discussed in Section c. above (see Photos 2 and 5).

e. Downstream Channel

The spillway discharges directly into the Knapp Brook Reservoir No. 1 (see Photos 6 and 9). The outlet pipe discharges slightly above the normal level of Reservoir No. 1 through what appears to be the old stream bed.

3.2 Evaluation

On the basis of the visual inspection, the dam is judged to be presently in good condition and well maintained. Of future concern are the movements of the retaining wall of the spillway discharge channel. The retaining wall movements are probably the result of frost action and are likely to continue in the future unless some corrective actions are taken as recommended in Section 7.2.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 Procedures

Both Knapp Brook Sites are operated by the Fish and Game personnel as fish management ponds. The operational procedures involve the controlling of the 4-foot by 2-foot sluice gate in the right side of the semicircular weir. The sluice gate is kept closed during the late spring and summer months and opened during the fall and winter months of the year. The only other controls exist at the intake structure where the 2-foot by 2-foot sluice gate is kept closed and the two stop log sets are in series. The stop logs are adjusted to permit low temperature draw-off in summer months.

4.2 Maintenance of Dam

The existing maintenance of the dam consists of periodic mowing of grass slopes on dam, removal of obstructions from the intake and spillway structures and yearly cutting of brush from the dam embankment.

4.3 Maintenance of Operating Facilities

The stop logs and two sluice gates are the only operating facilities and they appear to be in a well maintained condition. One of the wooden bridge posts should be replaced (see Section 3.1.c).

4.4 Description of Warning System in Effect

None exists for this dam.

4.5 Evaluation

The maintenance of the dam and structures is being carried out on a periodic basis. The dam is well maintained.

SECTION 5 - HYDRAULIC/HYDROLOGIC EVALUATION

5.1 Evaluation of Features

a. General

The Knapp Brook Site No. 2 Dam is an earth embankment dam with a clay core, built as a fish management project. It is a low surcharge storage - high spillage type dam.

b. Design Data

No design computations for the original construction in 1962 are available for the dam embankment. Hydrologic and hydraulic summary report for the spillway redesign in 1973 is included in Appendix B along with the design drawings for the original construction and spillway redesign. The semicircular weir was designed to behave as a drop structure due to the close proximity of natural ground at the left abutment upstream of the stream. The design criteria was to carry all or most of the 100-year flood of 1,050 CFS (362 CSM) in the chute spillway with a head of approximately 2 feet above the semicircular weir.

c. Experience Data

The June 30, 1973 flood was about 1.5 feet above the old concrete weir to elevation 110.5. This flood elevation yielded an estimated outflow of 720 CFS. This flood along with earlier floods, dates unknown, had produced significant erosion in the outlet channel downstream of the original weir.

d. Visual Observations

The primary spillway is a 20-foot radius semicircular weir with a concrete flume and flip bucket energy dissipator at its outlet. This semicircular weir is 2 feet lower than the original weir constructed in 1962. Located near the center of the dam is an outlet structure regulated by both stop logs and a 2-foot by 2-foot sluice gate. Access to the outlet works is by a service bridge which had a broken support. There was no debris observable and the outlet channels were clear. Of concern however, was observable horizontal displacement which has taken place at the construction joints of the chute walls along the lower portions of the outlet channel.

e. Test Flood Analysis

The test flood selected for Knapp Brook Site No. 2 was one-half of the Probable Maximum Flood and was chosen because the dam

is classified as being small in size with a significant hazard. The test flood inflow of 4,500 CFS (1,560 CSM) produced a routed test flood outflow of 4,360 CFS. The test flood elevation would be 111.8 feet with 3,100 CFS flowing through the spillway chute and 1,260 CFS flowing in the old spillway channel. The dam would not be overtopped, but the old spillway channel could erode and the present spillway chute could be undermined.

f. Dam Failure Analysis

If the Knapp Brook Site No. 2 Dam were to fail with the water level at the top of the dam, a flood wave of 8,330 CFS would be released into the pond behind Knapp Brook Site No. 1 Dam. The dam break routed through the Knapp Brook Site No. 1 pond would produce an outflow of 5,340 CFS and overtop the Knapp Brook No. 1 Dam by 2.1 feet.

The wave would be approximately 90 feet wide and about 3 feet over the banks or 1 foot over the first floor of the nearest home which is .8 miles downstream. There are an additional three homes scattered along Knapp Brook which could suffer minor structural damage as the flood wave would be about 1 foot over the stream banks, if this dam were to fail. The flood wave would rapidly diminish once it enters the broad flood plain of the North Branch of the Black River.

SECTION 6 - STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observations

The visual inspection did not disclose any immediate stability problems in the dam.

b. Design and Construction Data

There is not enough design and construction data available for the dam to perform a formal stability analysis; the assessment of stability is solely based on the visual inspection.

c. Operating Records

There are no records available of significance with respect to the stability of the dam.

d. Post-Construction Changes

There are no known post-construction changes except for the construction of the new spillway at the left abutment and service bridge to intake structure.

e. Seismic Stability

The dam is located in Seismic Zone 2 and in accordance with the recommended Phase I guidelines does not warrant seismic analysis.

SECTION 7 - ASSESSMENT, RECOMMENDATIONS/ REMEDIAL MEASURES

7.1 Dam Assessment

a. Condition

On the basis of the visual inspection, the dam was found to be in good condition. The retaining walls of the spillway discharge channel have moved, probably as a result of frost action, and movement will likely continue unless some modifications are made.

b. Adequacy of Information

The available information was not sufficient for a thorough analysis and thus, the assessment of the condition of the dam is based principally on the visual inspection.

c. Urgency

The recommendations presented in Section 7.2 should be carried out within 1 year of receipt of this report by the owner.

d. Need for Additional Investigations

There is no need for additional investigations beyond those recommended in Section 7.2

7.2 Recommendations

Measures must be taken under the direction of a registered professional engineer qualified in dam design to prevent further movement of the retaining walls of the spillway discharge channel. The engineer may consider replacement of the backfill against the wall with a free-draining material and drilling of drain holes through the wall near its base. In this manner, frost action against the wall will be prevented. In addition, the concrete lined spillway capacity should be evaluated with regard to the need for greater flood capacity.

7.3 Remedial Measures

a. Operation and Maintenance Procedures

1. A formal warning plan should be prepared.

2. Intermediate supports underpinning the service bridge should be repaired or replaced and braced to prevent future ice damage.

3. Institute a biennial program of technical Inspections.

4. Monitor on a regular continuing basis until the seepage problem is resolved, the seepage on the right stream bank immediately downstream of the outlet structure for flow volume and evidence of possible soil transport.

5. Provide round-the-clock monitoring during periods of heavy rainfall or high project discharges.

APPENDIX A

VISUAL INSPECTION CHECK LIST

VISUAL INSPECTION CHECK LIST
PARTY ORGANIZATION

PROJECT KNAPP BROOK SITE NO. 2 DATE April 23, 1979

TIME 11:00 AM - 1:00 PM

WEATHER Sunny, Warm

W.S. ELEV. _____ U.S. ____ DN.S.

PARTY:	April 23, 1979		May 22, 1979	
1.	Walter A. Henry	D-H	Sherward G. Farnsworth	D-H
2.	Morris J. Root	D-H	Gonzalo Castro	GEI
3.	Sherward G. Farnsworth	D-H		
4.	Gonzalo Castro	GEI		
5.				

	PROJECT FEATURE	INSPECTED BY	REMARKS
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			

PERIODIC INSPECTION CHECK LIST

PROJECT KNAPP BROOK SITE NO. 2 DATE April 23, 1979

PROJECT FEATURE _____ NAME _____

DISCIPLINE _____ NAME _____

AREA EVALUATED	CONDITION
DAM EMBANKMENT	
Crest Elevation	113.0± feet (local datum).
Current Pool Elevation	105.0 feet.
Maximum Impoundment to Date	
Surface Cracks	None observed.
Pavement Condition	Not applicable.
Movement or Settlement of Crest	None observed.
Lateral Movement	None observed.
Vertical Alignment	Too irregular to judge.
Horizontal Alignment	Too irregular to judge.
Condition at Abutment	Good.
Indications of Movement of Structural Items on Slopes	Not applicable.
Trespassing on Slopes	Minimum - fishermen and snow machines.
Sloughing or Erosion of Slopes or Abutments	None observed.
Rock Slope Protection - Riprap Failures	Good condition of riprap for both upstream and downstream slopes.
Unusual Movement or Cracking at or Near Toe	None observed.
Unusual Embankment or Downstream Seepage	None observed.
Piping or Boils	None observed.
Foundation Drainage Features	None known.
Toe Drains	None known.
Instrumentation System	None known.
Vegetation	Downstream slope grass covered, well maintained.

PERIODIC INSPECTION CHECK LIST

PROJECT KNAPP BROOK SITE NO. 2 **DATE** April 23, 1979

PROJECT FEATURE _____ **NAME** _____

DISCIPLINE _____ **NAME** _____

AREA EVALUATED	CONDITION
DIKE EMBANKMENT	Not Applicable
Crest Elevation	
Current Pool Elevation	
Maximum Impoundment to Date	
Surface Cracks	
Pavement Condition	
Movement or Settlement of Crest	
Lateral Movement	
Vertical Alignment	
Horizontal Alignment	
Condition at Abutment and at Concrete Structures	
Indications of Movement of Structural Items on Slopes	
Trespassing on Slopes	
Sloughing or Erosion of Slopes or Abutments	
Rock Slope Protection - Riprap Failures	
Unusual Movement or Cracking at or Near Toes	
Unusual Embankment or Downstream Seepage	
Piping or Boils	
Foundation Drainage Features	
Toe Drains	
Instrumentation System	
Vegetation	

PERIODIC INSPECTION CHECK LIST

PROJECT KNAPP BROOK SITE NO. 2 **DATE** April 23, 1979

PROJECT FEATURE _____ **NAME** _____

DISCIPLINE _____ **NAME** _____

AREA EVALUATED	CONDITION
OUTLET WORKS - INTAKE CHANNEL AND INTAKE STRUCTURE	
a. Approach Channel	None observed, gate under water.
Slope Conditions	
Bottom Conditions	
Rock Slides or Falls	
Log boom	
Debris	
Condition of Concrete Lining	
Drains or Weep Holes	
b. Intake Structure	
Condition of Concrete	Good.
Stop Logs and Slots	Stop logs and gate.

PERIODIC INSPECTION CHECK LIST

PROJECT KNAPP BROOK SITE NO. 2 DATE April 23, 1979

PROJECT FEATURE _____ NAME _____

DISCIPLINE _____ NAME _____

AREA EVALUATED	CONDITION
OUTLET WORKS - CONTROL TOWER	Not applicable
a. Concrete and Structural	
General Condition	
Condition of Joints	
Spalling	
Visible Reinforcing	
Rusting or Staining of Concrete	
Any Seepage or Efflorescence	
Joint Alignment	
Unusual Seepage or Leaks in Gate Chamber	
Cracks	
Rusting or Corrosion of Steel	
b. Mechanical and Electrical	
Air Vents	
Float Wells	
Crane Hoist	
Elevator	
Hydraulic System	
Service Gates	
Emergency Gates	
Lightning Protection System	
Emergency Power System	
Wiring and Lighting System	

PERIODIC INSPECTION CHECK LIST

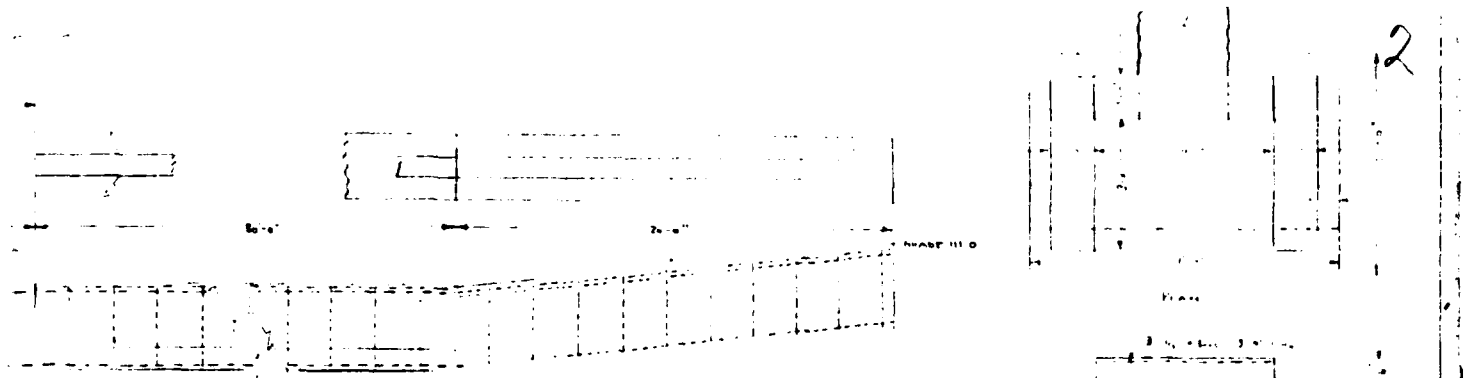
PROJECT KNAPP BROOK SITE NO. 2 **DATE** April 23, 1979

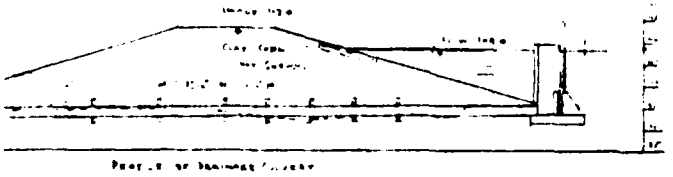
PROJECT FEATURE _____ **NAME** _____

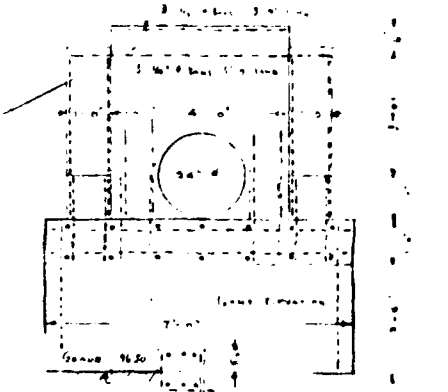
DISCIPLINE _____ **NAME** _____

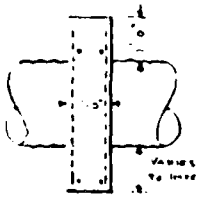
AREA EVALUATED	CONDITION
OUTLET WORKS - TRANSITION AND CONDUIT	Not applicable.
General Condition of Concrete	
Rust or Staining on Concrete	
Spalling	
Erosion or Cavitation	
Cracking	
Alignment of Monoliths	
Alignment of Joints	
Numbering of Monoliths	

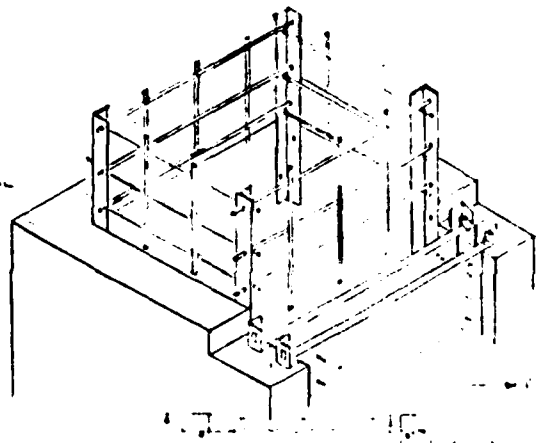
2

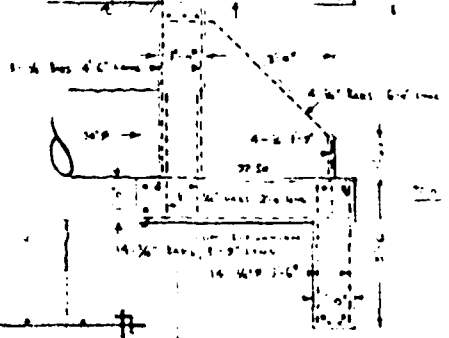


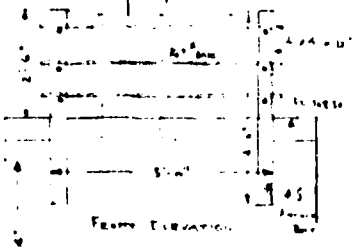


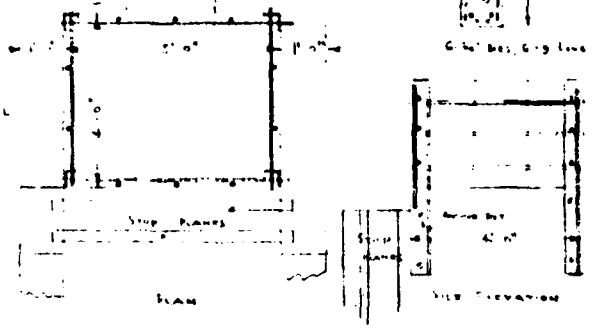


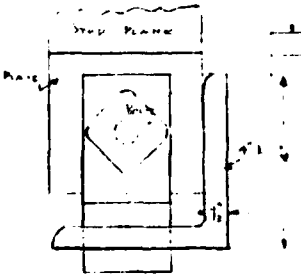


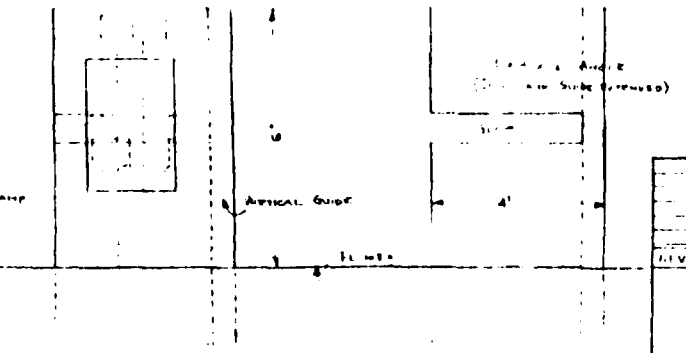












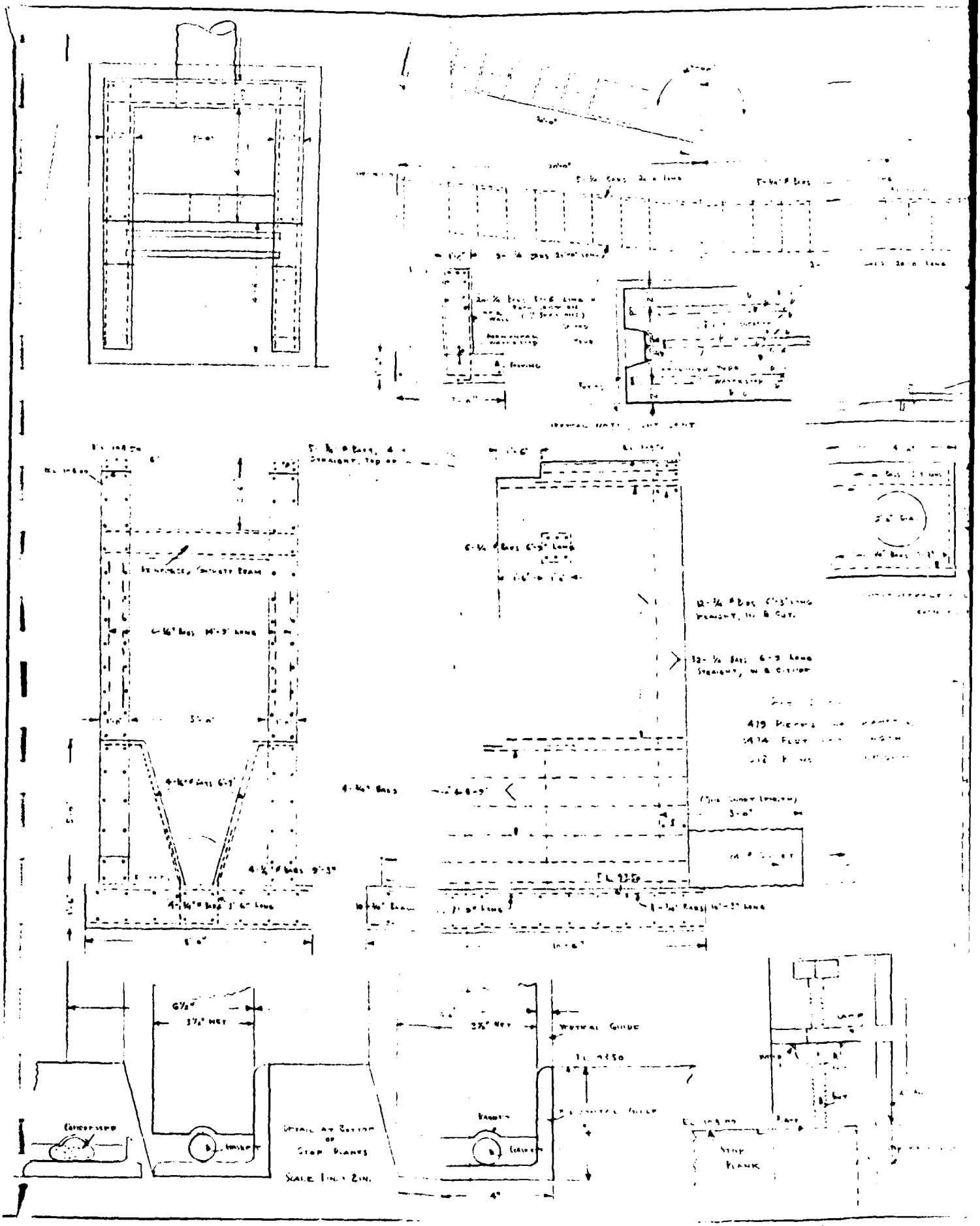
STATE OF VERMONT
FISH AND GAME COMMISSION

KNAPP BROOK RESERVOIR DAM
SITE NO 2

STRUCTURAL DETAILS

HALEY AND WARD
ENGINEERS
BOSTON MASS

DATE OCT. 1960 DWG. NO. SHEET 4 OF 4



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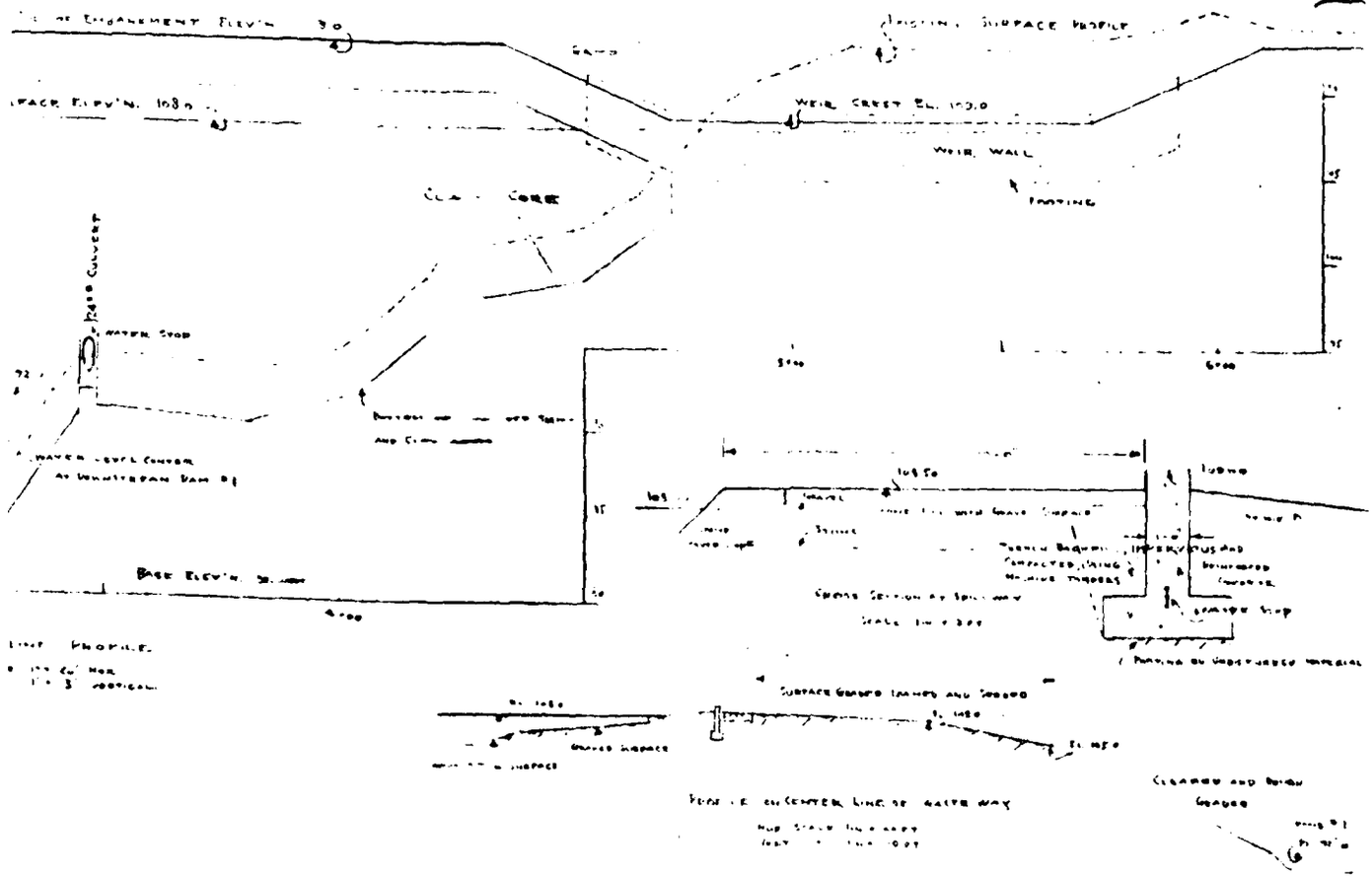
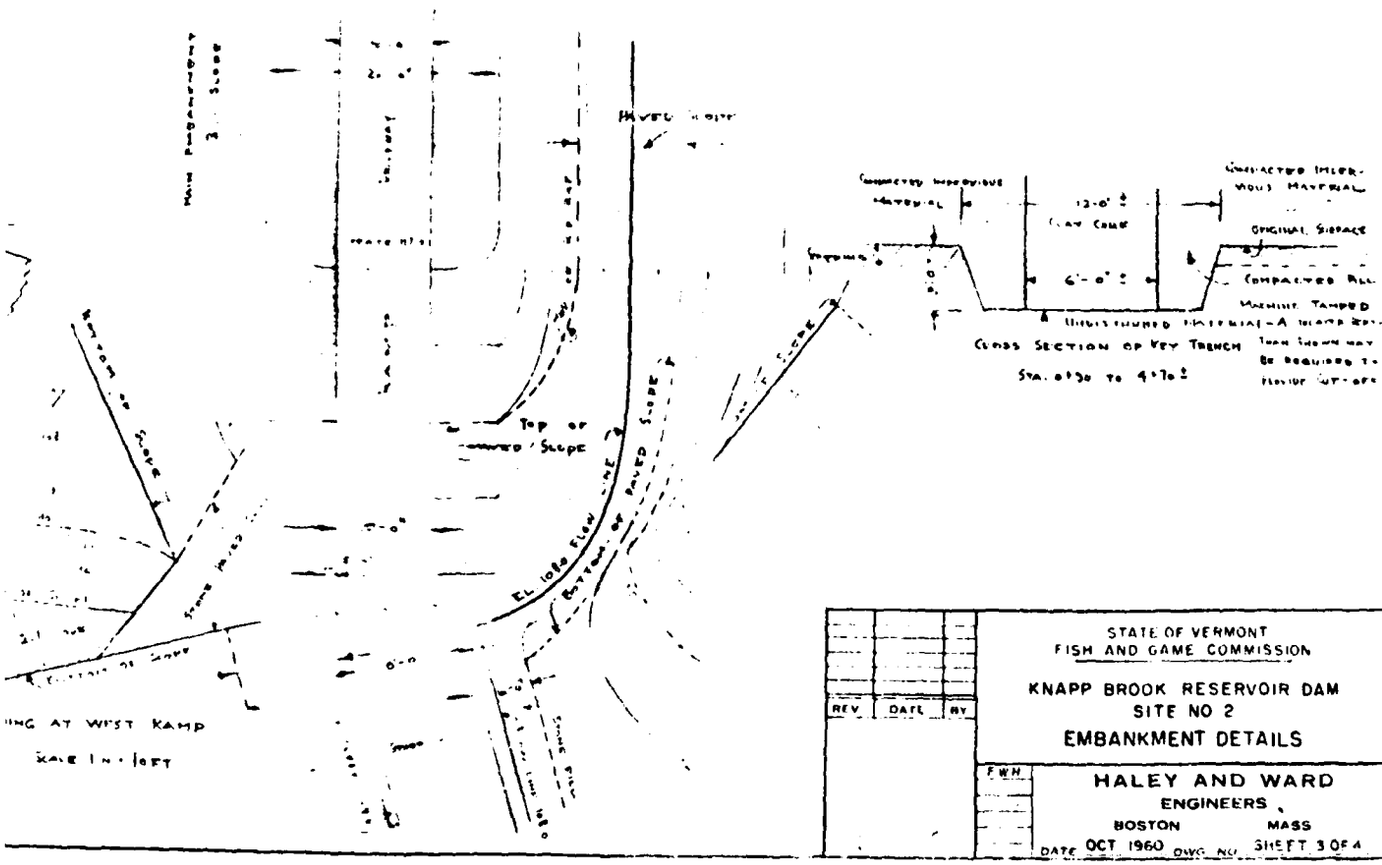




REV.	DATE	BY

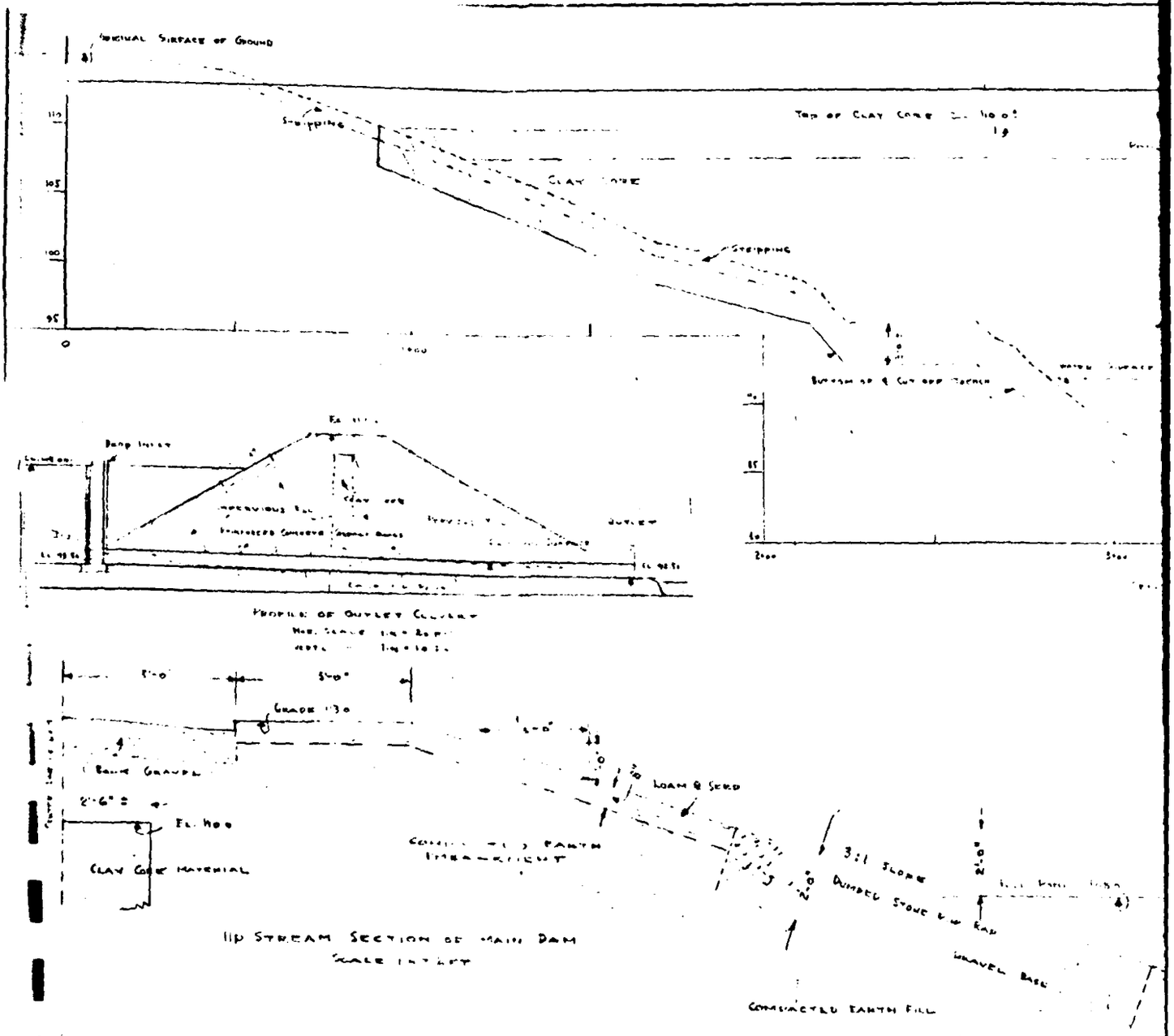
STATE OF VERMONT
FISH AND GAME COMMISSION

KNAPP BROOK RESERVOIR DAM
SITE NO 2
EMBANKMENT DETAILS

F.W.H.

HALEY AND WARD
ENGINEERS
BOSTON MASS

DATE OCT 1960 DWG. NO. SHEET 3 OF 4



PROFILE OF OUTLET CULVERT

Up Stream Section of Main Dam

Scale 1/4" = 1'-0"

2

REV	DATE	BY

STATE OF VERMONT
FISH AND GAME COMMISSION

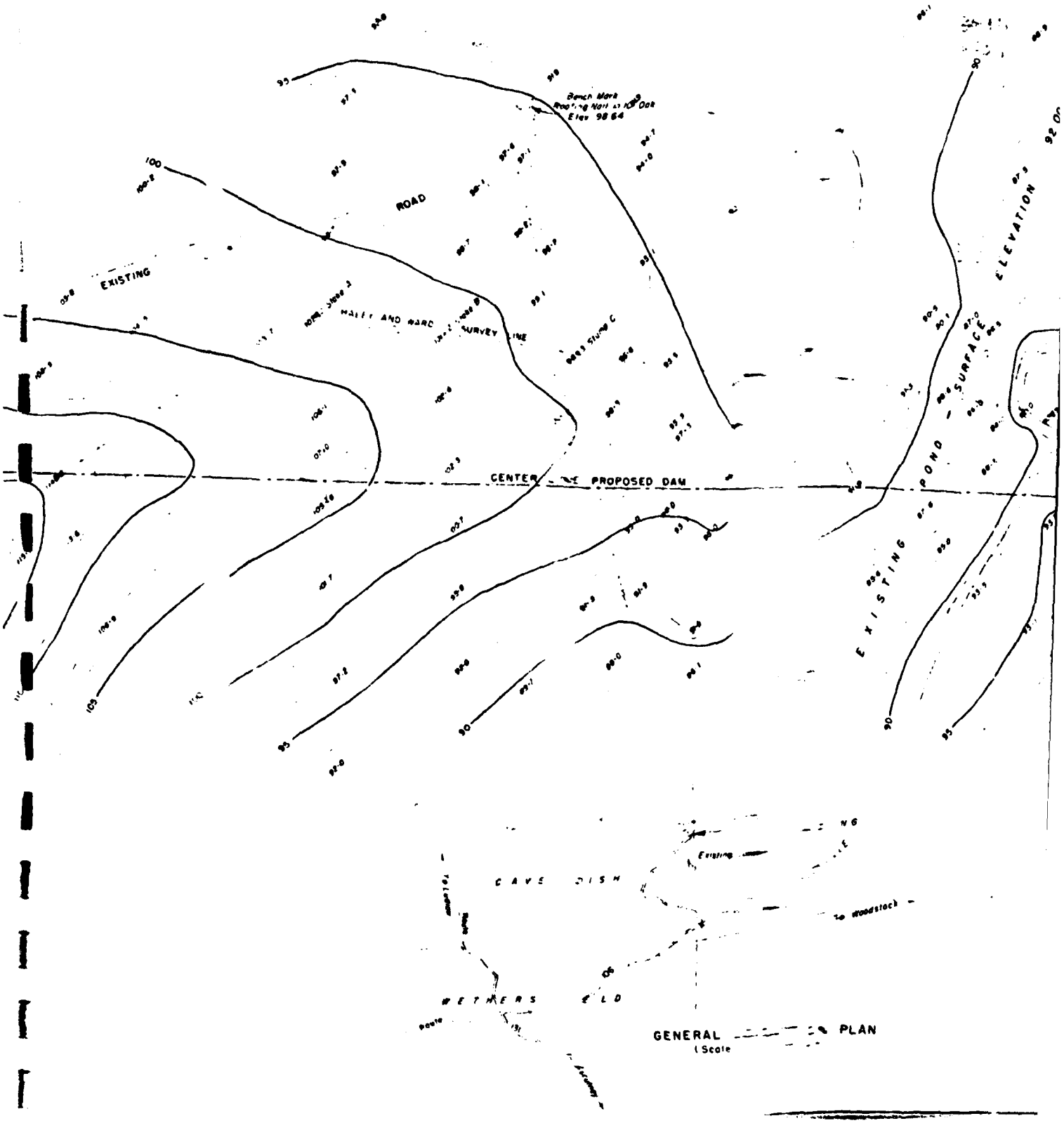
KNAPP BROOK RESERVOIR DAM
SITE NO 2

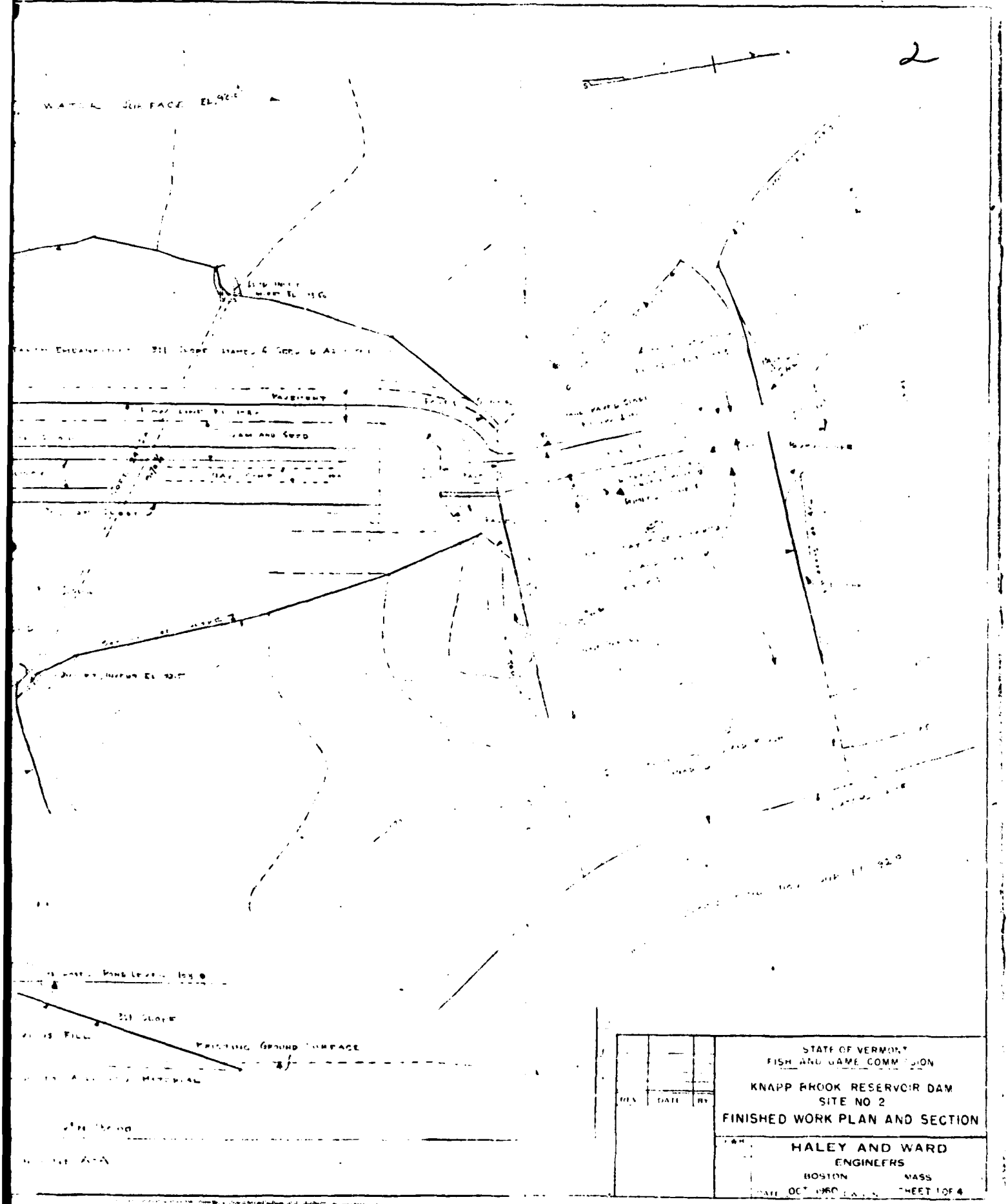
ORIGINAL SITE TOPOGRAPHY

R.P.H.

HALEY AND WARD
ENGINEERS
BOSTON MASS

DATE OCT 1980 DWG NO. SHEET 2 OF 4


Bench Mark
Elev 98.64
ROAD
EXISTING
HALEY AND WARD SURVEY LINE
CENTER LINE PROPOSED DAM
EXISTING POND SURFACE ELEVATION
CAVE DISH
Existing
to Woodstock
WETHERS FIELD
GENERAL PLAN
(Scale



NO.	DATE	BY

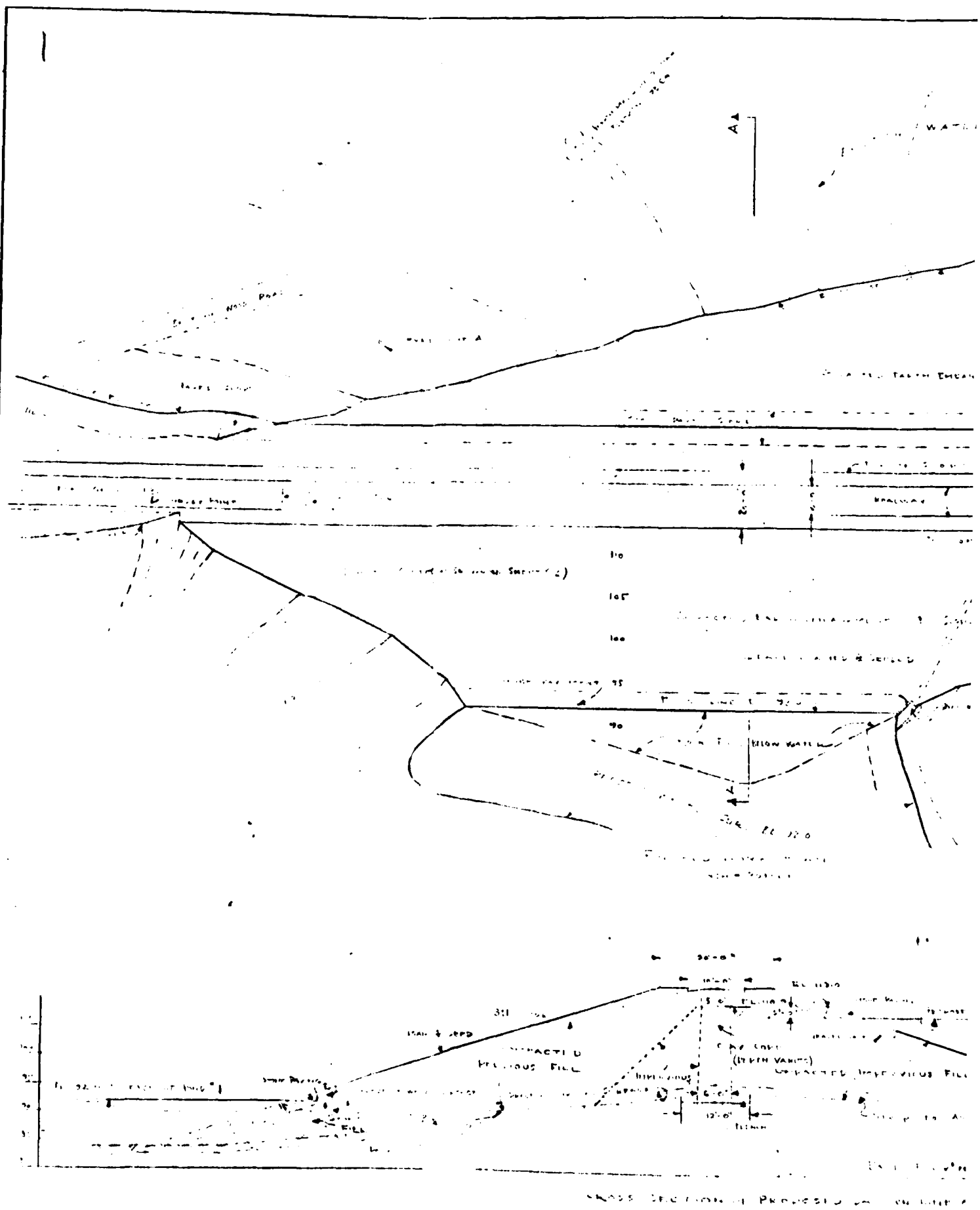
STATE OF VERMONT
FISH AND GAME COMMISSION

KNAPP BROOK RESERVOIR DAM
SITE NO 2

FINISHED WORK PLAN AND SECTION

HALEY AND WARD
ENGINEERS
BOSTON MASS

DATE OCT 1960 SHEET 1 OF 4


A
A
110
105
100
95
90
MEAN WATER
PERVIOUS FILL
(DEPTH VARIES)
UNCOMPACTED IMPERVIOUS FILL

STATE OF VERMONT

FISH AND GAME SERVICE

CONTRACT AND SPECIFICATIONS

for the

KNAPP BROOK RESERVOIR DAM

at

SITE NO. 2

in

CAVENDISH, WINDSOR COUNTY

OCTOBER 1960

FISH AND GAME COMMISSION

George L. Wright, Chairman
Quincy L. Perry
George H. Plumb
John H. Boylan
Edwin R. Fellows, II

George W. Davis, Director

Roger A. Seamans
Federal Aid Coordinator

Haley and Ward
Consulting Engineers
Boston, Mass.

APPENDIX B

PROJECT RECORDS AND PLANS

CONTENTS

PERIODIC INSPECTION CHECK LIST

PROJECT KNAPP BROOK SITE NO. 2 DATE April 23, 1979

PROJECT FEATURE _____ NAME _____

DISCIPLINE _____ NAME _____

AREA EVALUATED	CONDITION
RESERVOIR AREA	
Stability of Shoreline	Good.
Sedimentation	None observed.
Changes in Watershed Runoff Potential	None.
Upstream Hazards	None.
Downstream Hazards	Knapp Brook Site No. 1 Dam and houses below it.
Alert Facilities	None.
Hydrometeorological Gauges	None.
Operational and Maintenance Regulations	Fish management pond.

PERIODIC INSPECTION CHECK LIST

PROJECT KNAPP BROOK SITE NO. 2 **DATE** April 23, 1979

PROJECT FEATURE _____ **NAME** _____

DISCIPLINE _____ **NAME** _____

AREA EVALUATED	CONDITION
OUTLET WORKS - SERVICE BRIDGE	
a. Super Structure	
Bearings	Good condition.
Anchor Bolts	Spikes.
Bridge Seat	Not applicable.
Longitudinal Members	Good condition.
Underside of Deck	Good condition.
Secondary Bracing	None.
Deck	Good condition.
Drainage System	Not applicable.
Railings	Good condition.
Expansion Joints	None (short span).
Paint	Good condition.
b. Abutments and Piers	
General Condition of Concrete	Good.
Alignment of Abutment	Good.
Approach to Bridge	Not applicable.
Condition of Seat and Backwall	Not applicable.
Pier	One intermediate 4" x 4" wood support broken due to ice pressure.

PERIODIC INSPECTION CHECK LIST

PROJECT KNAPP BROOK SITE NO. 2 **DATE** April 23, 1979

PROJECT FEATURE _____ **NAME** _____

DISCIPLINE _____ **NAME** _____

AREA EVALUATED	CONDITION
OUTLET WORKS - EMERGENCY SPILLWAY WEIR APPROACH AND DISCHARGE CHANNELS	
a. Approach Channel	None.
General Condition	
Loose Rock Overhanging Channel	
Trees Overhanging Channel	
Floor of Approach Channel	
b. Weir and Training Walls	
General Condition of Concrete	Good, some minor cracks.
Rust or Staining	None observed.
Spalling	None observed.
Any Visible Reinforcing	None observed.
Any Seepage or Efflorescence	None observed.
Drain Holes	Drain holes located in base of concrete floor. No drain holes in training walls.
Construction Joints	Some lateral displacement of one inch.
Vertical Alignment	Inward tilting a maximum of 6 inches in 6 feet.
Backfill	Some settlement along both training walls.
c. Discharge Channel	
General Condition	Good.
Loose Rock Overhanging Channel	None.
Trees Overhanging Channel	None.
Floor of Channel	Concrete with subdrains.
Other Obstructions	

PERIODIC INSPECTION CHECK LIST

PROJECT KNAPP BROOK SITE NO. 2 **DATE** April 23, 1979

PROJECT FEATURE _____ **NAME** _____

DISCIPLINE _____ **NAME** _____

AREA EVALUATED	CONDITION
OUTLET WORKS - OUTLET STRUCTURE AND OUTLET CHANNEL	24" asphalt coated corrugated galvanized metal pipe.
General Condition of Concrete	Good.
Rust or Staining	None.
Spalling	None.
Erosion or Cavitation	None.
Visible Reinforcing	None.
Any Seepage or Efflorescence	Some seepage on right stream bank.
Condition at Joints	Not observed.
Drain Holes	None.
Channel	Natural.
Loose Rock or Trees Overhanging Channel	Minor overhang.
Condition of Discharge Channel	Good.

State of Vermont

tment of Fish and Game
tn[illegible]t of Forests and Parks
tn[illegible]t of Water Resources
nmental Board
on of Environmental Protection
on[illegible] Recreation
on[illegible] Planning
al Resources Conservation Council
ont Water Resources Board

AGENCY OF ENVIRONMENTAL CONSERVATION
MARTIN L. JOHNSON, Secretary
Montpelier, Vermont 05602
VERMONT WATER RESOURCES BOARD

1 August 1973

Mr. Andre Rouleau
Acting Director
Division of Management and Engineering
Vermont Department of Water Resources
Agency of Environmental Conservation
Montpelier, Vermont 05602

ROUTING		
GENERAL		
TO	NOTED	DATE
agl		
SUSPEND TO		
FILE		

Dear Andy:

Attached is a copy of a letter I received today from Ed Kehoe asking whether the Board needs to approve proposed repairs and redesigning of the emergency spillways at Knapp Pond # 2 and Kent Pond in accordance with the procedures specified in chapter 43 of Title 10, V.S.A. It would be helpful to the Board if you could prepare a brief memo on each of these structures explaining what damage they have suffered, whether it is imperative that the spillways be repaired before this winter, whether an alteration of an emergency spillway should be deemed an alteration of a dam for purposes of section 1082 of Title 10, and whether you think the procedures provided by chapter 43 must or should be followed for these two projects.

I know you are busy, but as soon as it is possible to prepare this I would like to have it. Thanks very much.

Sincerely,

W.H

VERMONT DEPARTMENT OF WATER RESOURCES

INFORMATION SHEET

ame of Dam Kaapp Brook Dam #2 Town Cavendish

wner Dept of Fish and Game Name of Stream Kaapp Brook

ddress Montpelier Classification II
Vermont

.S.G.S. Coordinates: Lat. 43°-26'-49" Long. 72°-34'-6"

.S.G.S. Map Ludlow Aerial Photos VT-62-H 36-232 233

.S.G.S. Elev. @ Spillway

'otal Length of Dam 540' Crest Width of Emergency Spillway 50'

Width of Top 20 ft. Maximum Height 30 ft.

Spillway Capacity: Principal 84 cfs @ DHWL Emergency 660 cfs @ DHWL

'ond Area 34 acres Drainage Area 2.88 sq mi

'ond Volume: Normal Water Level 108 ft Design High Water Level

Maximum Water Depth: Normal Water Level Design High Water Level

Storage Before Emergency Spillway is Used

Use of Reservoir Fish propagation; public recreation

Description of Dam: Earth fill w/clay core 3 on 1 slope on each face

Description of Spillway(s): P.S. Drop inlet with 24" ϕ concrete barrel with stop planks (1'x5' concrete box). E.S.- earth cut w/concrete weir wall across control section

Designed by Haley and Ward Eng Co Year Built 1962

Hearing Date April 8, 1961 Order Date April 2, 1962

Additional Remarks:

State of Vermont

AGENCY OF ENVIRONMENTAL CONSERVATION

MARTIN L. JOHNSON, Secretary

Montpelier, Vermont 05602

DEPARTMENT OF FISH AND GAME

ir ient of Fish and Game
irtment of Forests and Parks
irtment of Water Resources
ro mental Board
sic of Environmental Protection
sion of Recreation
sion of Planning
ir. Resources Conservation Council

July 31, 1973

Mr. Will Irwin,
Executive Secretary
Water Resources Board
Montpelier, Vt.

Dear Mr. Irwin:

In 1962 Knapp Pond #2 was built by the Fish and Game Department. The design of the pond had an emergency spillway which took care of any surplus water.

During the flood of July, 1973, the emergency spillway became unsafe for holding water. It is our plan to design a more secure emergency spillway.

Due to the fact that the pond should be filled during the winter these emergency spillways have to be built so that we can fill the pond to preserve the rest of the dam and outlet structure from damage by frost.

In 1962 Kent Pond was built by the Fish and Game Department. This pond also had an emergency spillway located in a different section of the pond from the main impoundment. During this same flood this emergency spillway was completely washed out and will have to be redesigned and rebuilt by winter.

We would hope that we do not have to go through the Water Resources Board to accomplish this.

Very truly yours,

Edward F. Kehoe,
COMMISSIONER

EFK/a

November 5, 1973

File

KNAPP BROOK POND #2

CAVENDISH, VERMONT

Reference is made to the Damage Survey Report dated October 2, 1973, which is determined ineligible. I disagree with the determination, the amount for restoration or repair, and the justification for determining eligibility. The reasons follow:

1. Eligibility

The statement, "It appears that the primary purpose of Knapp Brook Res. #2 is wildlife conservation," is apparently the basis for determining eligibility. Sec. 252 (c) PL 606 only mentions "exclusively used for recreation" as being ineligible. Impoundments which are constructed offstream could meet this description, but Knapp Brook Pond #2 is an on-stream impoundment, and consequently does alter the flow characteristics in the stream. The effect of any impoundment is to reduce peak flows and increase base flows. The magnitude of the impact can be determined, but does require some relatively complex computations, known as flood routing. An approximation can be used which usually is reliable, however.

a. Peak Flows

The greatest reduction in peak flows occurs at the dam itself, and becomes less significant with the distance from the dam due to diminishing impact of the impoundment. It is my considered opinion that Q_{10} flows are reduced approximately 40%, Q_{50} flows are reduced approximately 20%, and Q_{100} flows are reduced approximately 10%. The impact at various points on Knapp Brook and Black River are shown in Table I.

b. Low Flows

The impoundment, by virtue of having stored water, has the potential of being used to augment low flows if needed. This would have to be weighed

against possible adverse effect on the primary purpose, however.

c. Other Public Benefits

There are very few ponds in this portion of the state, and consequently the ones that exist are more significant than in areas with a large number of lakes and ponds. It is available for water supply (not necessarily potable) and fire protection in the immediate area.

Cost Estimate for Emergency Repairs and Permanent Restoration

The modifications necessary at the dam have been designed by the firm of Dufresne-Henry of North Springfield, Vermont. Plans and engineer's estimate are available. Included in the plans are two gates which give a potential for drawdown in anticipation of flood flows. These are above the "pre-disaster" criteria.

Damages Downstream of Dam

There is approximately 1½ miles of Town Road below the dam which was partly washed out during the June 30, 1973 flood. There are two homes in the flood plain, and other homes which depend on this road for access. There is approximately $34,000 in DSR's for category A, B, and C in the area, which would have been much higher if the Knapp Brook Ponds had not been there. The Vermont National Guard was at the area for several days, logging over 600 man hours of work plus use of equipment, etc. Evacuation of some people was made due to the uncertain condition of the dam during and after the flood. The dam remains in an unsafe condition and is entirely drawn down to minimize the probability of utilizing the emergency spillway. It is a continuing threat to the public safety in its present condition.

4. Other Exceptions to Damage Survey Report

Page 1 of 3 (computations) - Elevations given as MSL, which usually means

mean sea level. These elevations are from an assumed datum, not mean sea level.

Page 3 of 3 - Nearest damage center is from the dam to the confluence of Knapp Brook and North Branch of Black River. Knapp Brook Pond is to Springfield, Vermont as any one of the Corps Flood Control Dams by itself is to Hartford, Connecticut - insignificant.

Andie J. Rouleau

Nov 5, 1973

Knapp Brook Pond Dam, Site #2 - Cavendish

Edward F. Kehoe, Commissioner, Dept. of Fish & Game

Donald H. Spies, Dam Construction Engineer, Dept. of Water Resources

September 22, 1972

On September 21, 1972, the writer made an inspection of the subject structure. The dam is an earth fill structure with a drop inlet and a two foot CMP for a principal spillway. The drop inlet has stop logs to control the water level. The emergency spillway is an earth channel with a concrete weir for the control section.

The dam is in good shape, but does have some saplings growing in the riprap on the downstream toe. The emergency spillway, though, is in bad shape. In addition to a number of large logs that are scattered on the crest, the downstream channel has undergone severe erosion. This should be corrected so that it doesn't work its way back further. A possible solution would be to dig up this portion of the spillway and refill it with boulders 18" to 24" in size. Then fill the voids with 1" to 3" stones.

cc: Robert Collins, Maintenance Supervisor
Richard Sears, Land Negotiator

ROUTING

GENERAL

TO	NOTED	DATE
DHS	DHS	9-22-72
JEC	JEC	

SUSPEND

FILE ✓

MONTPELIER, VERMONT

ROUTING

GENERAL		
TO	NOTED	DATE
RWT		
TEC	[illegible]	4-20
[illegible]	[illegible]	4-20-62
SUSPENSE TO		
FILE		

OFFICE MEMORANDUM

DATE: April 20, 1962

TO: Donald W. Webster

SUBJECT: Report on Spring Runoff at Knapp Brook Dams and Bridges Downstream

On April 19, 1962, the writer and John Cerutti viewed the above mentioned site.

First, the roadway culvert downstream of the Hasson's was checked. This was the culvert that had washed out this spring. Previous to last fall, there was a wood plank bridge at this site. The bridge had a clear span of 23' and a height of opening of 7', giving a waterway area of 161 square feet. After the bridge was damaged, a "squash" pipe 3' 8" high by 6' 0" wide was substituted. This pipe has a waterway area of 17.6 square feet, or about one-ninth of the former bridge. The drainage area above this culvert is 4.11 square miles, of which 0.70 square miles are between Knapp Brook Dam #1 and the culvert.

Apparently, there are no cutoff collars on the pipe, and there is definite seepage along the pipe. It appears that when the pipe was emplaced, the roadway fill was simply pushed over the pipe and not properly compacted. It is also doubted that the pipe was properly bedded. There are no headwalls, training walls or aprons on either the upstream or downstream ends of the pipe.

In all probability, this pipe and adjoining roadway will fail during any heavy summer downpour due to insufficient capacity.

Our investigation showed that the partial failure of Knapp Brook Dam #2 had nothing whatsoever to do with the failure of the road culvert downstream from Hasson's.

At Knapp Brook Dam #1, the water surface was about 4 feet below the top of the outlet structure. During the peak runoff it was about 2 feet higher so that at no time did any water go out through the emergency spillway.

At Knapp Brook Dam #2, about 7 feet of water (between elevations 98.00 and 105.00 feet) could have gone out through the breach in the dam caused by the overtopping of the unfinished dam.

The unfinished dam had been built up to about elevation 105.00 feet on the downstream side (eight feet below design height of the finished dam) and sloped away toward the upper side so that the elevation at the centerline of the dam was about 103.50 feet.

The breach occurred in the area between the outlet structure and the emergency spillway. The area which washed out was about 20 feet wide at the upstream side of the dam and widened to about 60 feet on the lower side.

It appears that the escaping water was contained by the previously drawn down Knapp Brook Dam #1.

WF-34

GENERAL

TO	INITIALS	DATE
[illegible]	-	1/7/74
[illegible]	[illegible]	1/7/74
DHS	[illegible]	1-7-74
SEC.	[illegible]	

SUSPEND TO

FILE

MANAGEMENT & ENGINEERING DIVISION

MEMORANDUM

To: Cathy Bothwell, Executive Secretary, Water Resources Board

From: Andre Rouleau, Assistant Director, M & E Division

Subject: Kent Pond Dam and Knapp Pond Dam #2

Date: January 7, 1974

It has just come to my attention that we have an outstanding request from Will Irwin regarding the above captioned dams (copy attached). Here are our comments that Will asked for:

The damage at both dams during the flood of June 30, 1973, was in the emergency spillways. It consisted of severe erosion of the earth spillway, causing a partial failure to the spillway. This kind of partial failure becomes worse every time water flows over the emergency spillway. It is possible that the emergency spillway may not be utilized for several years, but on the other hand, it could be required to pass water at any time. The Fish & Game Department, at our request, has lowered the water level in both ponds so that the ponds are almost empty and have only nominal conservation pools at the present time.

It is very important that the emergency spillway be repaired so that complete failure would not occur. The Fish & Game Department has retained consultants to re-design the emergency spillways. The firm of Dufresne-Henry is doing the work at Knapp Pond Dam #2 and the firm of DuBois & King is doing the work at Kent Pond Dam. The design has been reviewed by our office and there is no substantial change to the purpose of the impoundments, although the emergency spillways will now be controlled by concrete and rock fill, as opposed to being an excavation and to original ground as they were previously. This is the only practical way of correcting the situation.

I do consider this as a significant alteration of a dam and I further consider it to be emergency work. Both projects are now under construction with the critical phases scheduled for completion prior to the spring runoff. The procedures provided by Chapter 43 should be followed for both of these projects. However, time is not available for these procedures due to the critical conditions remaining while the matter is being considered.

We would be pleased to brief the Board on all aspects of the projects if they are interested. Another possibility is for the Board to issue an emergency order for the work which is being done.

Please advise if I can be of any further assistance.

AJR/kmp

Rebuilt Knapp Pond Dams a Possibility

FROM:
RUTLAND DAILY HERALD
WED. MORNING
JULY 18, 1973

By MARY BARTON

CAVENDISH — (Special) — State officials feel that two earthen dams on Knapp Pond here should probably be replaced, and would like the job done by this fall, so the small lake can be ready for fishing next spring.

That was the message Fish & Game Commissioner Edward F. Kehoe brought to a small gathering of local selectmen and residents here Tuesday night. The meeting was scheduled to discuss the future of the two structures on the pond.

No opposition was expressed to replacing the earth dams, though one local man, James Hasson, felt the structures had performed admirably in the recent floods. Water flowed over the top of one dam during the second highwater period, the week after the disastrous June 30 flood, but both structures held.

The small bodies of water behind the two dams, which together constitute Knapp Pond, are drained now, and Commissioner Kehoe revealed other plans that would involve a $10,000 reclamation of the lake, to provide good fishing for next year.

The problem with the time schedule is that Water Resources Board hearings will be necessary if a local person requests them. Such hearings, Kehoe warned Tuesday, could push back the deadline three to four months, making the spring fishing objective unrealistic. No one had concrete reports of hearing requests Tuesday.

The first dam was built in 1958, and contains 38 acres of water. The second earthwork, built in 1965, floods 26 acres. Together they hold about 63 million gallons of water. They both have clay cores.

The structures were built to provide fishing ponds, not as flood control dams, and the recent overflow had state officials skittish. Kehoe said the newer dam suffered $50,000 damage to the emergency spillway because of high water.

The dams are owned by the Fish & Game Department, but any changes in the construction require Water Resources Board approval. In addition to rebuilding the restrainers, and the reclamation project, Kehoe suggested a joint Water Resources Board-Fish & Game Department surveillance of streams that feed the pond.

A constant watch on streambeds would enable officials to spot problems and prevent flooding. The commissioner said he opposed "channelization," manmade watercourses. They hurt the fish, Kehoe said.

A detailed engineering survey of the Knapp Pond dams would cost about $13,000, according to Dufresne & Henry, a North Springfield firm. The firm, through Walter A. Henry, listed four steps for the survey.

The first would be a detailed study of the drainage pattern in the pond, with examinations of 10-year and 100-year storm patterns. The price for this would be $3,000.

Step two is dependent on the first procedure. If the drainage examination warranted it, $5,000 would be spent for a three-stage study of new structures: $1,000 for a soil investigation, $1,000 for a basin survey, and $3,000 for project design.

The third step described by the engineer would cost $2,000, for professional consulting at Water Resources Board hearings on rebuilding the dams.

Last would be a $3,000 fee for overseeing construction. Kehoe offered no figure on construction costs, and indicated the federal government would pay for the new dams.

Cavendish Selectmen Richard Tucker and John Stearns agreed the pond should remain as long as it is safe. That was the general feeling at the Tuesday session.

Kehoe said that if plans were designed correctly, there would be little difficulty in rebuilding the structures. If the Water Resources Board okays the project, bids would be let out immediately, the commissioner added.

The dams are located on Knapp Pond Road here, off Tarbell Hill Road, near the Reading border.

Kehoe said he would report back to selectmen here when he heard from other state people.

KNAPP POND DAM

GENERAL

From observation, on June 30, 1973 water appeared to have been between one and 1.5 feet over the weir crest on the emergency spillway and these flows resulted in a substantial amount of erosion on the earthen spillway face. If the water had been 1.5 feet over the weir crest, the discharge of Knapp Brook would have been approximately 720 cfs, which corresponds to an event somewhere between the 30- and 50-year recurrence interval, as can be seen by observing the attached probability plot. An event of this magnitude corresponds favorably to the stream flows recorded at Beaver Brook in Wilmington, Vermont, and Flood Brook in Londonderry, Vermont, on the same date.

Flood Magnitude and Frequency

The frequency of these stream flows was established by comparison with the regionalized analysis available in both the Bureau of Public Roads' publication "Peak Rates of Runoff - New England, New York and New Jersey" and the U.S. Geological Survey Water-Supply Paper, No. 1671, "Magnitude and Frequency of Floods in the United States." The small drainage areas involved necessitated the use of a log-log extrapolation of the data available in the U.S.G.S. publication to establish the mean annual flood and engineering judgment to establish the ratios of floods with greater magnitudes.

Based on the attached probability plot, a 10-year peak discharge of 410 cfs and a 100-year peak discharge of about 1050 cfs was used. The hydrograph experienced at Sonny Brook in Montpelier on June 30, 1973 was modified to produce a peak of 410 cfs and routed through both Knapp Ponds based on the existing lower dam and designed upper dam by using the Modified Puls Technique for reservoir routing. Similarly, the hydrograph experienced at Flood Brook, Londonderry, in August 1966, was modified to correspond to a peak discharge of 1050 cfs and routed through the ponds. The inflow-outflow hydrographs for these events are attachments to this report.

Further, the hydrograph from Snyder's Synthetic Hydrograph Technique was compared to the 100-year flow hydrograph. The inflow hydrograph appeared to be conservative in that the base flow of 60 cfs presupposed fairly wet antecedent conditions along with the relatively long lag to the peak and shallow slope of the recession phase. The unit hydrograph generated by Snyder's Technique compared favorably to the unit hydrograph derived from the June 30, 1973 event on Flood Brook.

An analysis of the culverts on the Knapp Pond access road reveals that the ponds prevent the road from being damaged annually, but the 72-inch by 44-inch pipe-arch culvert in the vicinity of the James Hasson residence will be topped on the average of once in three years, and the 6-foot corrugated metal culvert upstream will be topped on the average of once in seven years based on the capability of the ponds to reduce the peaks of storms similar to the 10-year event by roughly 23%.

Routing and Structural Comparisons

Several alternate structures have been considered and evaluated using the Modified Puls Technique for reservoir routing. Many computations were made with the assumption that the effective surface area for the pond was 35 acres. When data became available, it was noted that the surface area varied according to the following table:

Surface Area of Knapp Pond No. 2

Stage*	Surface Area
110 feet	40.3 acres
108 feet	38.0 acres
106 feet	35.5 acres

* Based on 108.5-foot datum top of existing inlet structure.

The 24-inch diameter corrugated metal culvert's capacity was computed using "Indirect Measurement of Peak Discharge Through Culverts," a 1963 open-file report by the U.S.G.S., as was the conservation of an additional 42-inch diameter culvert which was one of the design alternatives.

Formulae for broad-crested weirs and critical depth computations are contained in King's "Handbook of Hydraulics."

The alternatives evaluated were:

1. Using the existing facility with a normal pool at the 108-foot elevation;

2. A 30-foot weir at the 106-foot elevation with the pond normally at elevation 103 feet;

3. A 42-inch diameter culvert in addition to the present pipe, normal pond 106.0 feet;

4. A system of weirs and break-away stop logs, pool at 104.0 feet;

5. A 42-inch diameter culvert in addition to the present pipe, normal pond at 103.0 feet;

6. A siphonic spillway with (see Bureau of Reclamation, "Design of Small Dams") a throat depth of 3 feet and 6 feet wide, normal pool at 103.0 feet;

7. A box inlet drop structure 33.3 x 33.3 x 33.3 (see Henderson, "Open Channel Flow" pp. 198-202), normal pool at 103.0 feet.

The peak flows for the alternatives are given in the following table:

100-YEAR PEAK OUTFLOWS FOR ALTERNATE STRUCTURES OF KNAPP POND DAM NO. 2 (INSTANTANEOUS PEAK INFLOW 1050 cfs)

Alternative	#1	#2	#3	#4	#5	#6	#7
Instantaneous Peak Outflow (cfs)	1040	955	955	880	850	550	1030

Erosion is going to be a recurring problem on a spillway constructed of earth, as the slopes vary from 3% to 25% at present. Noncohesive material, at least 6 inches in diameter, would be required on the 3% slope assuming the depth is at critical from drawdown of the weir. On the lower face, the worst condition occurring at the break in slope, material required would be at least 3.3 feet in diameter. These boulders would have to be grouted in place. Any alternative will require that the existing spillway be stabilized or, by design, not utilized in any but a rarely occurring flood and then it should be understood erosion of the nature which occurred in 1973 will happen.

As this was intended to be a fish propagation pond, it should be noted that, according to Chow, "Handbook of Applied Hydrology," ponds used for this purpose require a wide shallow spillway to reduce the loss of fish. Instead of a normal design depth of about 2 feet, the depth of flow on a fish pond spillway crest should be less than 0.5 foot. Freeboard of 1 or 2 feet is usually added to the design depth. At this point, it should be brought to light that the emergency spillway designed by Haley & Ward will carry the 100-year flood at approximately the 110.9-foot stage (1.9 feet above the existing weir crest). Any 30-foot weir

against possible adverse effect on the primary purpose, however.

c. Other Public Benefits

There are very few ponds in this portion of the state, and consequently the ones that exist are more significant than in areas with a large number of lakes and ponds. It is available for water supply (not necessarily potable) and fire protection in the immediate area.

2. Cost Estimate for Emergency Repairs and Permanent Restoration

The modifications necessary at the dam have been designed by the firm of Dufresne-Henry of North Springfield, Vermont. Plans and engineer's estimate are available. Included in the plans are two gates which give a potential for drawdown in anticipation of flood flows. These are above the "pre-disaster" criteria.

3. Damages Downstream of Dam

There is approximately 1½ miles of Town Road below the dam which was partly washed out during the June 30, 1973 flood. There are two homes in the flood plain, and other homes which depend on this road for access. There is approximately $34,000 in DSR's for category A, B, and C in the area, which would have been much higher if the Knapp Brook Ponds had not been there. The Vermont National Guard was at the area for several days, logging over 600 man hours of work plus use of equipment, etc. Evacuation of some people was made due to the uncertain condition of the dam during and after the flood. The dam remains in an unsafe condition and is entirely drawn down to minimize the probability of utilizing the emergency spillway. It is a continuing threat to the public safety in its present condition.

4. Other Exceptions to Damage Survey Report

Page 1 of 3 (computations) - Elevations given as MSL, which usually means

November 5, 1973

File

KNAPP BROOK POND #2

CAVENDISH, VERMONT

Reference is made to the Damage Survey Report dated October 2, 1973, which is determined ineligible. I disagree with the determination, the amount for restoration or repair, and the justification for determining eligibility. The reasons follow:

1. Eligibility

The statement, "It appears that the primary purpose of Knapp Brook Res. #2 is wildlife conservation," is apparently the basis for determining eligibility. PL 606 sec. 252 (c) only mentions "exclusively used for recreation" as being ineligible. Impoundments which are constructed offstream could meet this description, but Knapp Brook Pond #2 is an on-stream impoundment, and consequently does alter the flow characteristics in the stream. The effect of any impoundment is to reduce peak flows and increase base flows. The magnitude of the impact can be determined, but does require some relatively complex computations, known as flood routing. An approximation can be used which usually is reliable, however.

a. Peak Flows

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b. Low Flows

The impoundment, by virtue of having stored water, has the potential of being used to augment low flows if needed. This would have to be weighed

State of Vermont

AGENCY OF ENVIRONMENTAL CONSERVATION

MARTIN L. JOHNSON, Secretary

Montpelier, Vermont 05602

DEPARTMENT OF FISH AND GAME

July 31, 1973

artment of Fish and Game
artment of Forests and Parks
artment of Water Resources
ironmental Board
sion of Environmental Protection
sion of Recreation
sion of Planning
ural Resources Conservation Council

Mr. Will Irwin,
Executive Secretary
Water Resources Board
Montpelier, Vt.

Dear Mr. Irwin:

In 1962 Knapp Pond #2 was built by the Fish and Game Department. The design of the pond had an emergency spillway which took care of any surplus water.

During the flood of July, 1973, the emergency spillway became unsafe for holding water. It is our plan to design a more secure emergency spillway.

Due to the fact that the pond should be filled during the winter these emergency spillways have to be built so that we can fill the pond to preserve the rest of the dam and outlet structure from damage by frost.

In 1962 Kent Pond was built by the Fish and Game Department. This pond also had an emergency spillway located in a different section of the pond from the main impoundment. During this same flood this emergency spillway was completely washed out and will have to be redesigned and rebuilt by winter.

We would hope that we do not have to go through the Water Resources Board to accomplish this.

Very truly yours,

Edward F. Kehoe,
COMMISSIONER

EFK/a

State of Vermont

AGENCY OF ENVIRONMENTAL CONSERVATION

MARTIN L. JOHNSON, Secretary
Montpelier, Vermont 05602
VERMONT WATER RESOURCES BOARD

tm[it of Fish and Game
tr[at of Forests and Parks
tment of Water Resources
onmental Board
on Environmental Protection
on Recreation
on of Planning
al Resources Conservation Council
on Water Resources Board

1 August 1973

Mr. Andre Rouleau
Acting Director
Division of Management and Engineering
Vermont Department of Water Resources
Agency of Environmental Conservation
Montpelier, Vermont 05602

ROUTING		
GENERAL		
TO	NOTED	DATE
agl		
SUSPEND TO		
FILE		

Dear Andy:

Attached is a copy of a letter I received today from Ed Kehoe asking whether the Board needs to approve proposed repairs and redesigning of the emergency spillways at Knapp Pond # 2 and Kent Pond in accordance with the procedures specified in chapter 43 of Title 10, V.S.A. It would be helpful to the Board if you could prepare a brief memo on each of these structures explaining what damage they have suffered, whether it is imperative that the spillways be repaired before this winter, whether an alteration of an emergency spillway should be deemed an alteration of a dam for purposes of section 1082 of Title 10, and whether you think the procedures provided by chapter 43 must or should be followed for these two projects.

I know you are busy, but as soon as it is possible to prepare this I would like to have it. Thanks very much.

Sincerely,

W.M

We would be pleased to brief the Board on all aspects of the projects if they are interested. Another possibility is for the Board to issue an emergency order for the work which is being done.

Please advise if I can be of any further assistance.

AJR/kmp

V/

VERMONT DEPARTMENT OF WATER RESOURCES

INFORMATION SHEET

Name of Dam Knapp Brook Dam #2 Town Cavendish

Owner Dept of Fish and Game Name of Stream Knapp Brook

Address Montpelier Classification IV

Vermont

U.S.G.S. Coordinates: Lat. 43°26'-49" Long. 72°34'-6"

U.S.G.S. Map Ludlow Aerial Photos VT-62-H 36-232, 233

U.S.G.S. Elev. @ Spillway

Total Length of Dam 540' Crest Width of Emergency Spillway 50'

Width of Top 20 ft. Maximum Height 30 ft.

Spillway Capacity: Principal 84 cfs @ DHWL Emergency 660 cfs @ DHWL

Pond Area 34 acres Drainage Area 2.88 sq mi

Pond Volume: Normal Water Level 108 ft Design High Water Level

Maximum Water Depth: Normal Water Level Design High Water Level

Storage Before Emergency Spillway is Used

Use of Reservoir Fish propagation, public recreation

Description of Dam: Earth fill w/clay core & 3 on 1 slope on each face

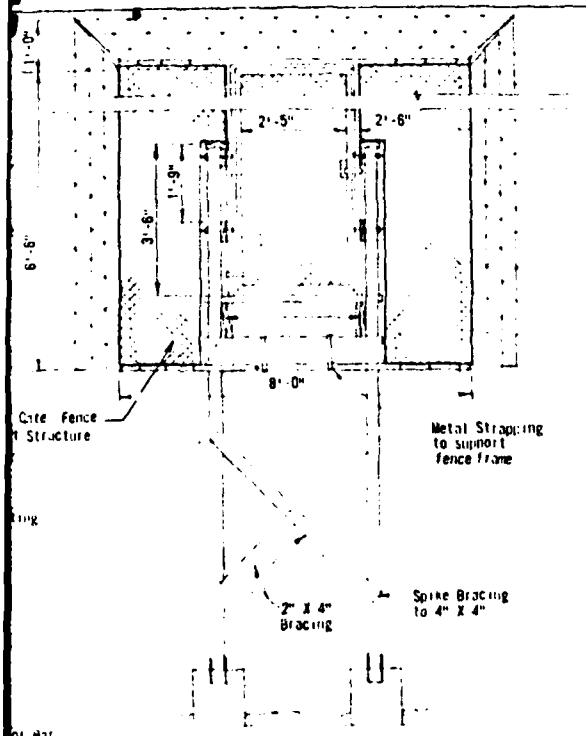
Description of Spillway(s): PS Drop inlet with stop planks (4'x5' concrete box). 24"Ø concrete barrel. E.S.-earth cut w/concrete weir wall across control section.

Designed by Haley and Ward Eng Boston Year Built ~~1963~~ 1962

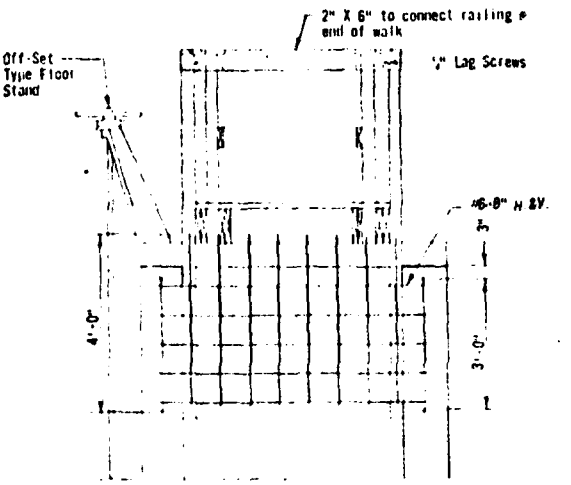
Hearing Date April 18, 1961 Order Date April 2, 1962

Additional Remarks:

2

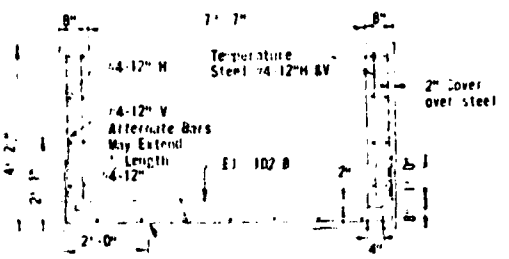


SECTION A A
1" = 1'-0"

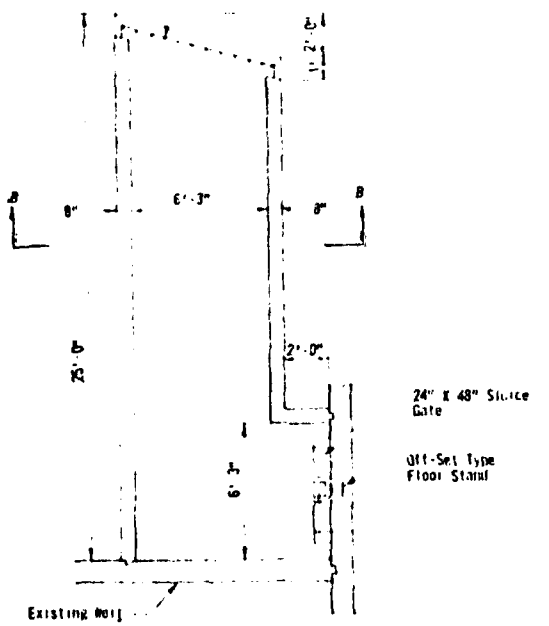


ELEVATION - WALK AND SPILLWAY
1/2" = 1'-0"

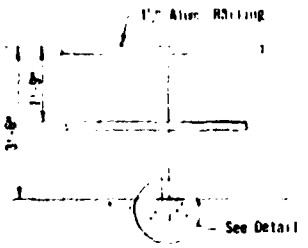
Bar Screen (See Detail This Sheet)



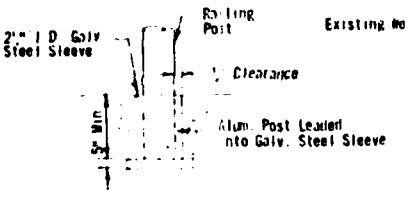
SECTION B B
1" = 1'-0"



SERVICE OUTLET WORKS
1" = 1'-0"



ALUM RAILING POST
N T S



ALUM RAILING POST ANCHORAGE
N T S

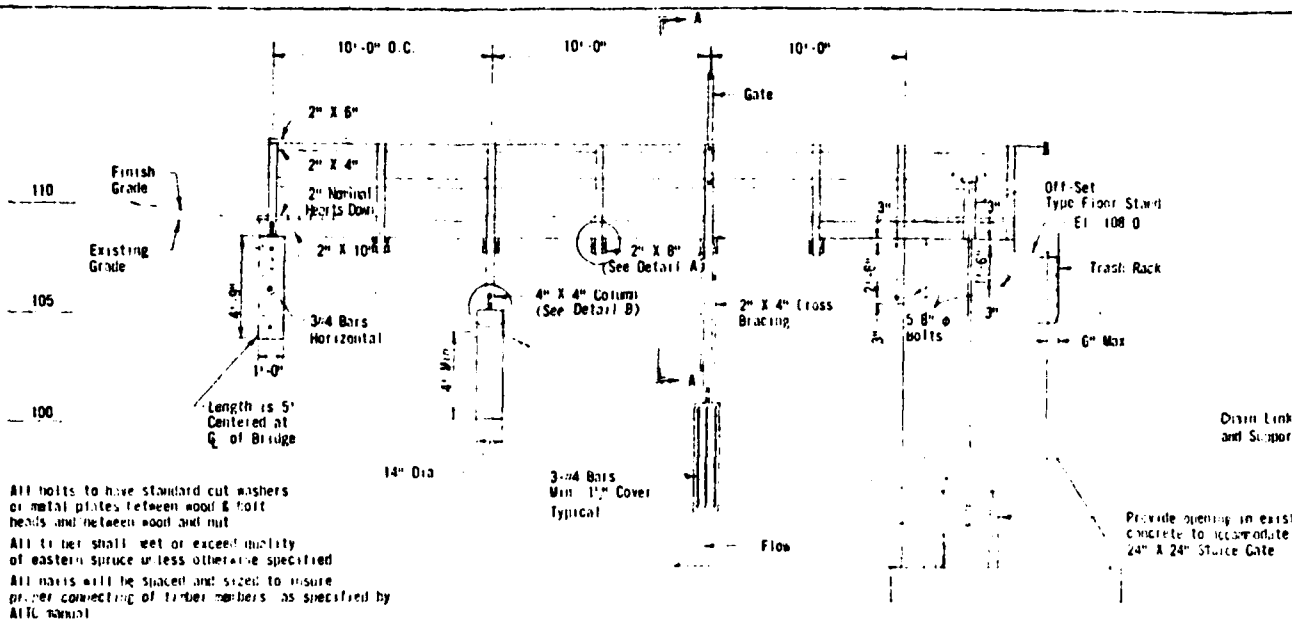
KNAPP POND DAM
MISCELLANEOUS DETAILS

Cavendish, Vermont

DUFRESNE-HENRY
Engineering Corporation
REGISTERED PROFESSIONAL CIVIL & SANITARY ENGINEERS
PRECISION PARK NORTH SPRINGFIELD VERMONT

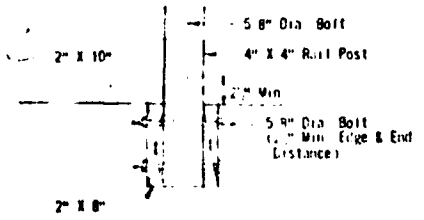
DRAWING NO.	3-9021		DESIGN SHEET M. R. Petruso
SURVEY CREW			SCALE As Shown
PLOTTED BY	TLM	10-26-73	SHEET 3 OF 3
TRACED BY	TLM	10-30-73	DATE October 31, 1973
CHECKED BY	MRP	10-31-73	APPROVED

11/15/73

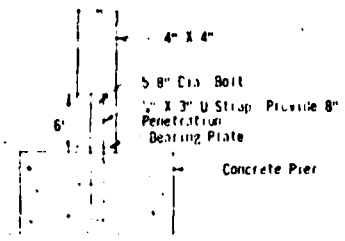


NOTES
1) All bolts to have standard cut washers or metal plates between wood & bolt heads and between wood and nut
2) All timber shall meet or exceed quality of eastern spruce unless otherwise specified
3) All bars will be spaced and sized to insure proper connecting of timber members as specified by AITC manual

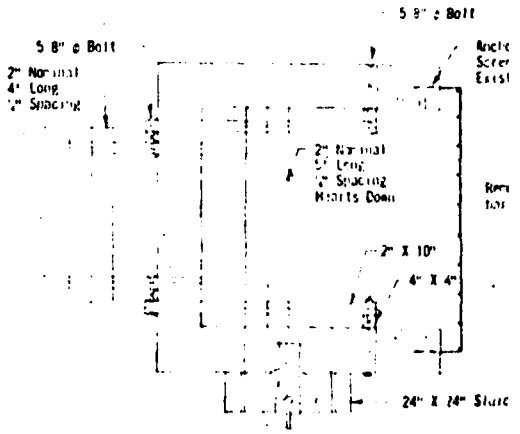
FOOT BRIDGE ELEVATION
1" = 1'-0"



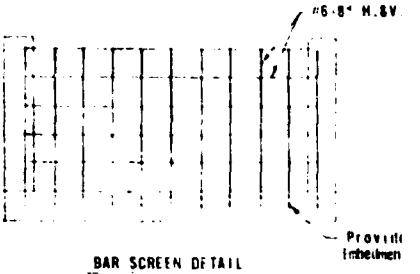
RAILING POST CONNECTION DETAIL A
N T S



COLUMN TO PIER CONNECTION DETAIL B
N T S

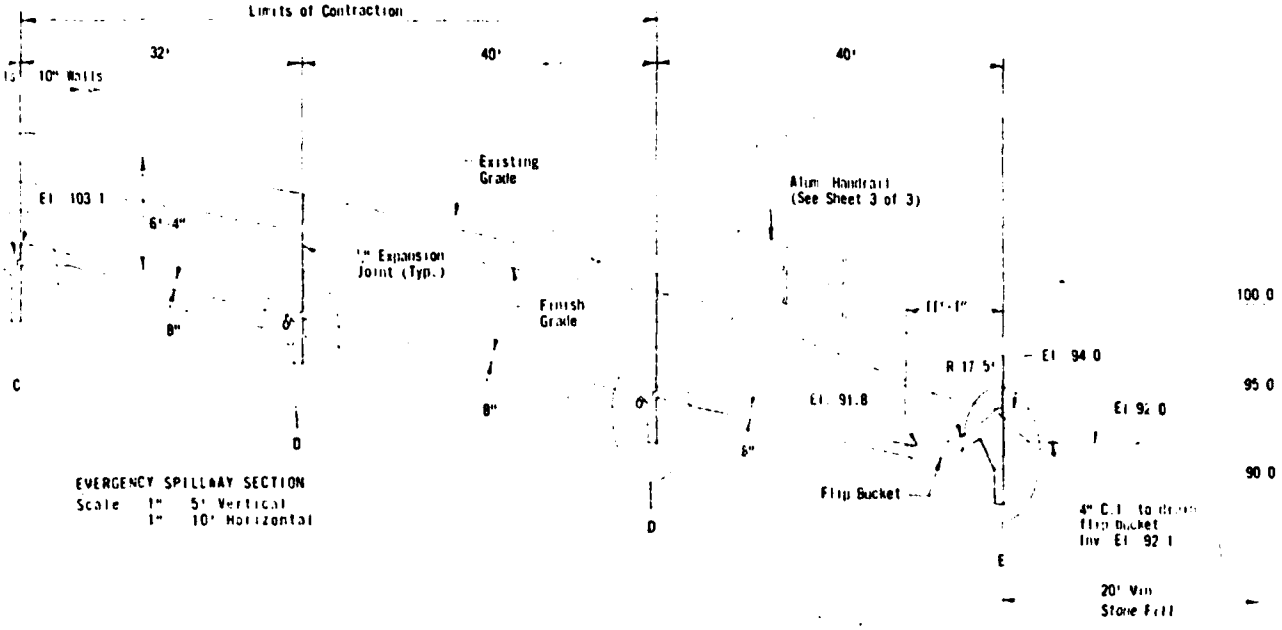


PLAN OF WALK AND SPILLWAY
1" = 1'-0"

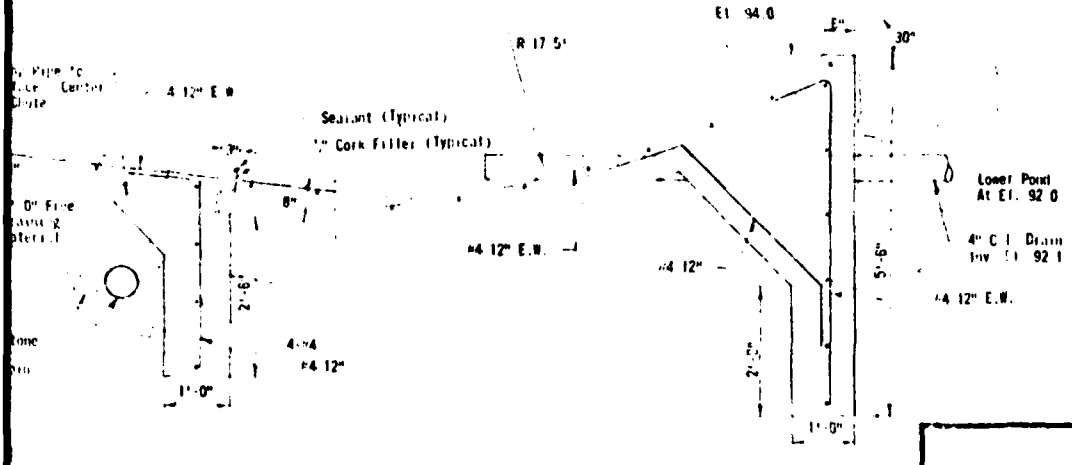


BAR SCREEN DETAIL
FOR SERVICE OUTLET WORKS
1" = 1'-0"

2

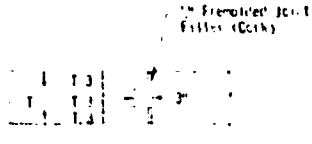


EVERGENCY SPILLWAY SECTION
Scale 1" 5' Vertical
1" 10' Horizontal



DETAIL D
1" = 1'-0"

DETAIL E
1" = 1'-0"

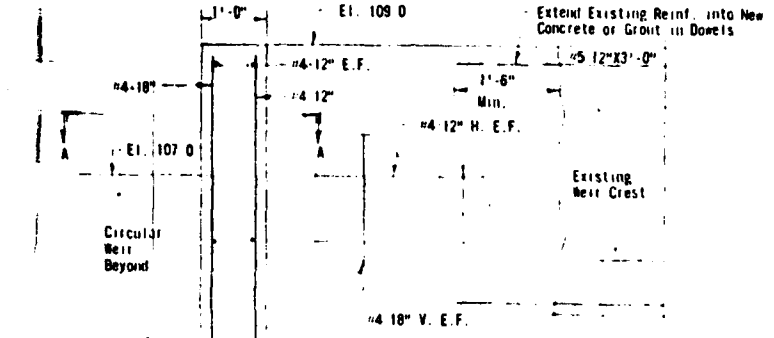


TYPICAL WALL EXPANSION JOINT DETAIL
N T S

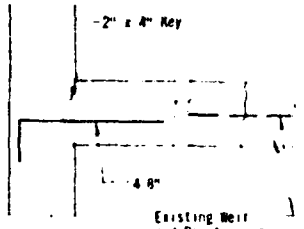
KNAPP POND DAM
STRUCTURAL DETAILS
Cavendish, Vermont

DUFRESNE-HENRY
Engineering Corporation
CIVIL & SANITARY ENGINEERS
PRECISION PARK NORTH SPRINGFIELD VERMONT

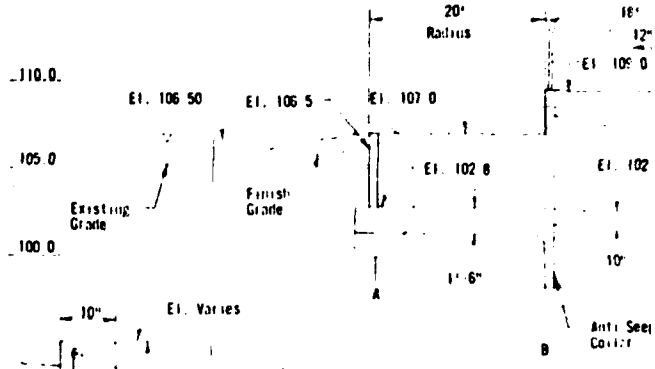
DRAWING NO	3-0021	DESIGN CHKD	
SURVEY CHKD		SCALE	As Shown
PLOTTED BY	TLM 10-23-73	SHEET	OF
TRACED BY	TLM 10-23-73	DATE	September 1973
CHECKED BY	MHF 10-[illegible]	APPROVED	

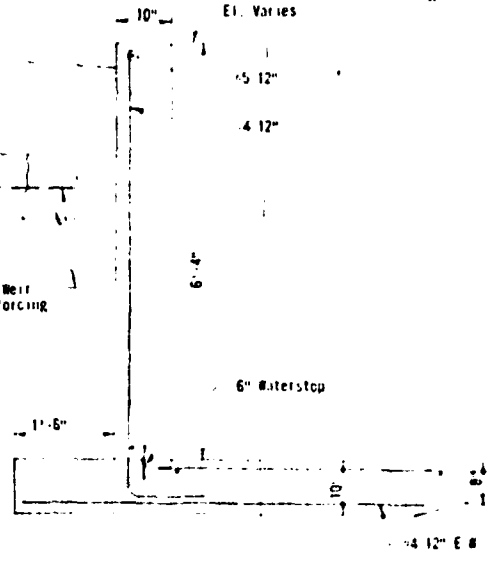


ANTI-SEEP COLLAR DETAIL
1/4" = 1'-0"

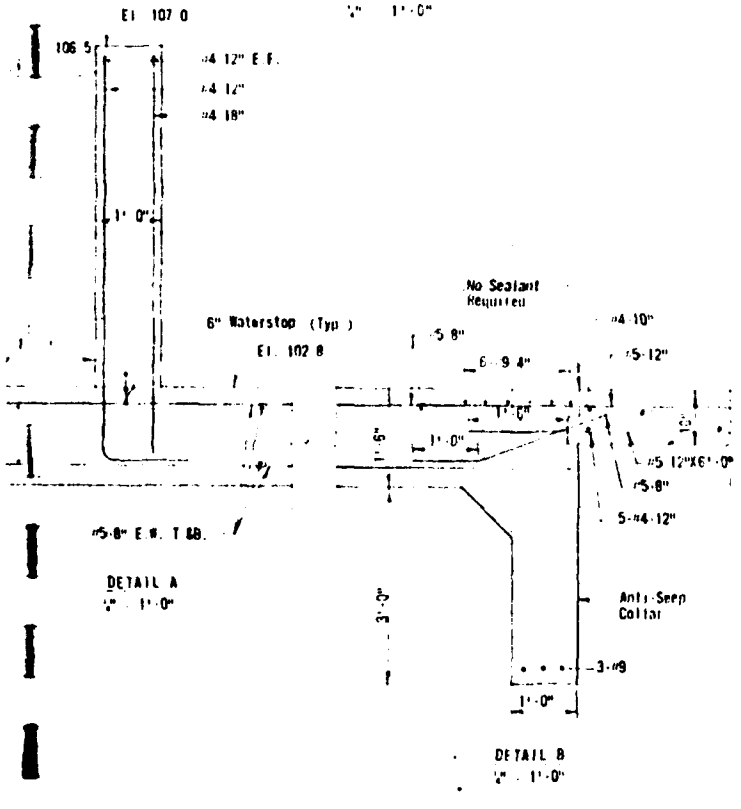


SECTION A-A
1/4" = 1'-0"



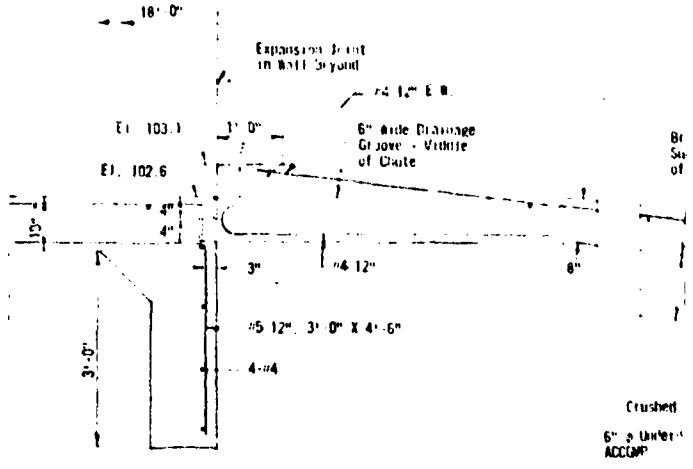


TYPICAL SECTION THRU CHUTE WALLS
1/4" = 1'-0"



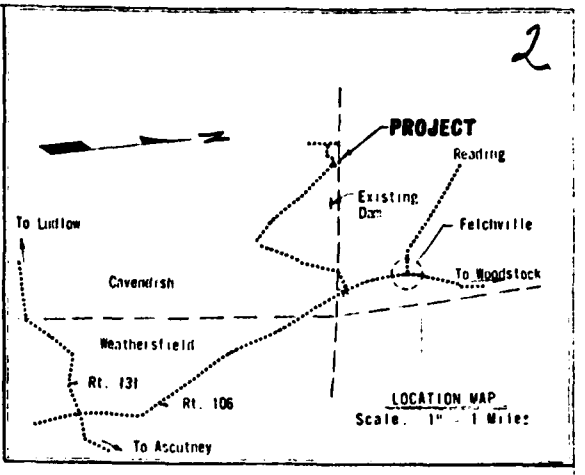
DETAIL A
1/4" = 1'-0"

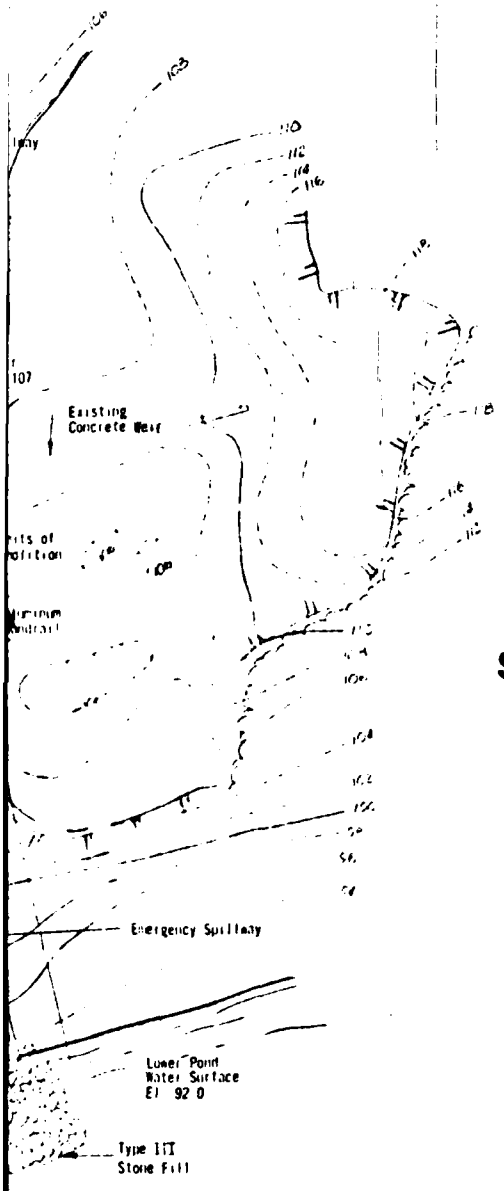
DETAIL B
1/4" = 1'-0"



DETAIL C
1/4" = 1'-0"

2





LEGEND

Proposed Contour

Existing Contour

Water Edge

KNAPP POND DAM EMERGENCY SPILLWAY STRUCTURE & TOWER IMPROVEMENTS

CAVENDISH, VERMONT

FOR

THE STATE OF VERMONT DEPT. OF FISH & GAME

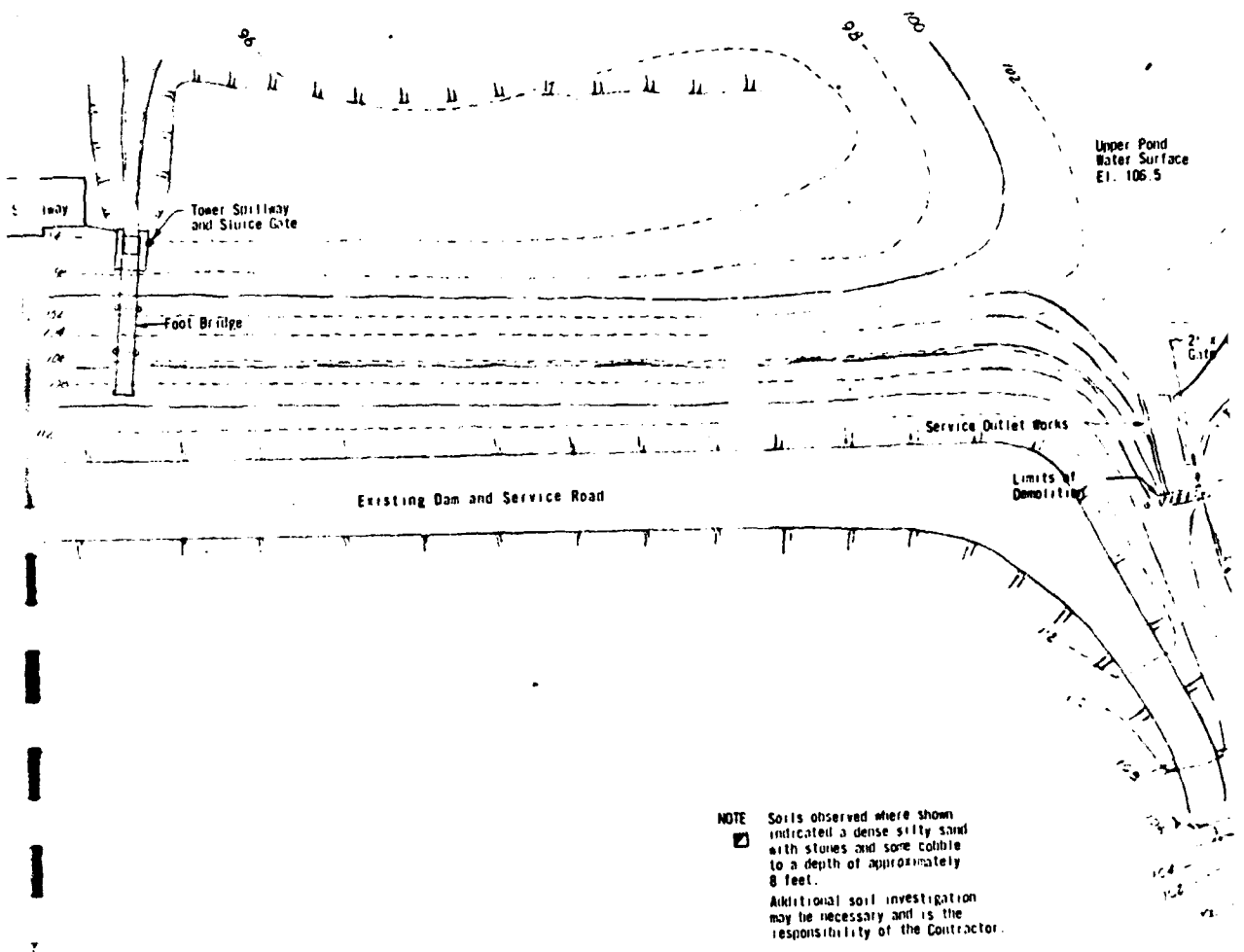
MONTPELIER, VERMONT

KNAPP POND DAM
PROJECT PLAN

Cavendish, Vermont

DUFRESNE-HENRY
Engineering Corporation

	7902/1		W. K. Peloso
	CS		1" = 2Ø'
	EHC	9 28 73	1 of 3
	TEW	10 2 73	October 31, 1973


Upper Pond
Water Surface
El. 106.5
Tower Spillway
and Sluice Gate
Foot Bridge
Service Outlet Works
Existing Dam and Service Road
Limits of
Demolition
NOTE
Soils observed where shown
indicated a dense silty sand
with stones and some cobble
to a depth of approximately
8 feet.
Additional soil investigation
may be necessary and is the
responsibility of the Contractor.

From the above table, it is estimated that the June 30, 1973 Flood on Knapp Brook was roughly equivalent to a 50-year event. As in the preliminary study, where the hydrograph derived by Snyder's Method showed the August 1966 Flood Brook hydrograph as modified to be conservative, the hydrograph observed on 30 June 1973 at Flood Brook produced a peak shortly after the peak intensity of rainfall was experienced. If such an event were experienced at Knapp Pond, such that the peak occurred prior to filling of the pond to the spillway crest, a limited amount of flood control will be realized.

The drop structure was designed using the empirical technique set forth in Henderson, "Open Channel Flow," and checked by the data available in the Bureau of Reclamation, "Design of Small Dams." Both computations showed that the drop inlet and stilling basin are designed in such a manner that the flow will be stabilized by a hydraulic jump prior to leaving the stilling basin. The mean annual flood will flow at a depth of approximately 9 inches over the semi-circular weir crest. Other depths of flow are available upon request.

The 100-year peak flow line in the spillway chute was computed by standard backwater computation procedures and the final width of the contraction was selected so that choking of the flow will not occur. Further, the angle of contraction satisfies the criteria set forth by "Design of Small Dams."

At the spillway terminus, a hydraulic jump stilling basin was considered, but would not have been feasible since the conjugate depth would have required a deeper channel and definitive methods for energy dissipation by free discharge into the lower pond were not available. The flip bucket was also designed by the criteria established by the Bureau of Reclamation and will, under a 100-year peak flow, have the jet impinge roughly 15 feet away from the lip of the bucket. Lower flows will not travel as far; hence, riprap approximately 4 feet in diameter will be dumped to a finished grade of not greater than 20% in the lower pond, starting from the lip of the flip bucket to a distance of about 20 feet from the lip.

MJR
November 29, 1973

or combination of weirs and stop logs will carry water at depths in excess of 4 feet.

CONCLUSIONS

Paving the 100-foot wide spillway may cost in excess of $50,000, based on a rough estimate of 500 cubic yards required. The spillway will have to be stabilized if only a larger culvert is installed; thus, there will be an added cost for those alternatives.

The flood peak reduction for most alternatives is not substantial enough to warrant introducing the likelihood of frequent fish losses. Consequently, a spillway, or drop structure, that will conform to fish propagation criteria should be designed. The costs are approximately equal for paving the existing spillway or installing a box inlet drop structure with a 33-foot channel through the face of the present emergency spillway.

FINAL SPILLWAY DESIGN

For reasons of providing a safe dam, improving flow chacteristics and fish propagation, it was decided a semi-circular inlet drop structure with a contracting channel would be the most economical solution to the spillway design in terms of amounts of concrete required.

The final design was checked on the basis of comparison of the flow estimates of these three analytical techniques: the NEHL Method, data available in USGS Water Supply Paper No. 1671, and the 1961 Bureau of Public Roads' publication "Peak Rates of Runoff from Small Watersheds." The peak rates of runoff by the first two methods were similar for all frequencies, and the 1961 Bureau of Public Roads' technique gave a 100-year peak rate equivalent to the other two. The peak rates are as given in the table below:

Recurrence Interval (years)	2.33	5	10	25	50	100
Instantaneous Peak Inflow (cfs)	185	280	410	620	810	1050

ean sea level. These elevations are from an assumed datum, not mean sea level.

Page 3 of 3 - Nearest damage center is from the dam to the confluence of Knapp brook and North Branch of Black River. Knapp Brook Pond is to Springfield, Vermont as any one of the Corps Flood Control Dams by itself is to Hartford, Connecticut - insignificant.

André J. Rouleau

Nov 5, 1973

TABLE I

KNAPP BROOK POND #2 - HYDROLOGIC DATA

(NEHL CHARTS)

Location	Drainage Area	Q_{10} w/o Pond	Q_{10} With Pond	% Reduction	Q_{50} w/o Pond	Q_{50} With Pond
Knapp Brook Pond #1	3.4	470	280	40	850	680
napp Brook at Mouth	5.0	650	460	29	1,200	1,030
North Branch of Black River at Confluence of Knapp Brook	25.0	1,830	1,640	10	3,440	3,270

Knapp Brook Pond Dam, Site #2 - Cavendish

Edward F. Kehoe, Commissioner, Dept. of Fish & Game

Donald H. Spies, Dam Construction Engineer, Dept. of Water Resources

September 22, 1972

On September 21, 1972, the writer made an inspection of the subject structure. The dam is an earth fill structure with a drop inlet and a two foot CMP for a principal spillway. The drop inlet has stop logs to control the water level. The emergency spillway is an earth channel with a concrete weir for the control section.

The dam is in good shape, but does have some saplings growing in the riprap on the downstream toe. The emergency spillway, though, is in bad shape. In addition to a number of large logs that are scattered on the crest, the downstream channel has undergone severe erosion. This should be corrected so that it doesn't work its way back further. A possible solution would be to dig up this portion of the spillway and refill it with boulders 18" to 24" in size. Then fill the voids with 1" to 3" stones.

cc: Robert Collins, Maintenance Supervisor
Richard Sears, Land Negotiator

ROUTING

GENERAL

TO	NOTED	DATE
DHS	DHS	9-22-72
JEC	JEC	

SUSPEND

FILE ✓

GENERAL		
TO	INITIAL	DATE
DJL	-	1/7/74
DM	AM	1/7/74
DHS	DHS	1-7-74
SEC.	JLC	
SUSPEND TO		
FILE		

MANAGEMENT & ENGINEERING DIVISION

MEMORANDUM

To: Cathy Bothwell, Executive Secretary, Water Resources Board

From: Andre Rouleau, Assistant Director, M & E Division

Subject: Kent Pond Dam and Knapp Pond Dam #2

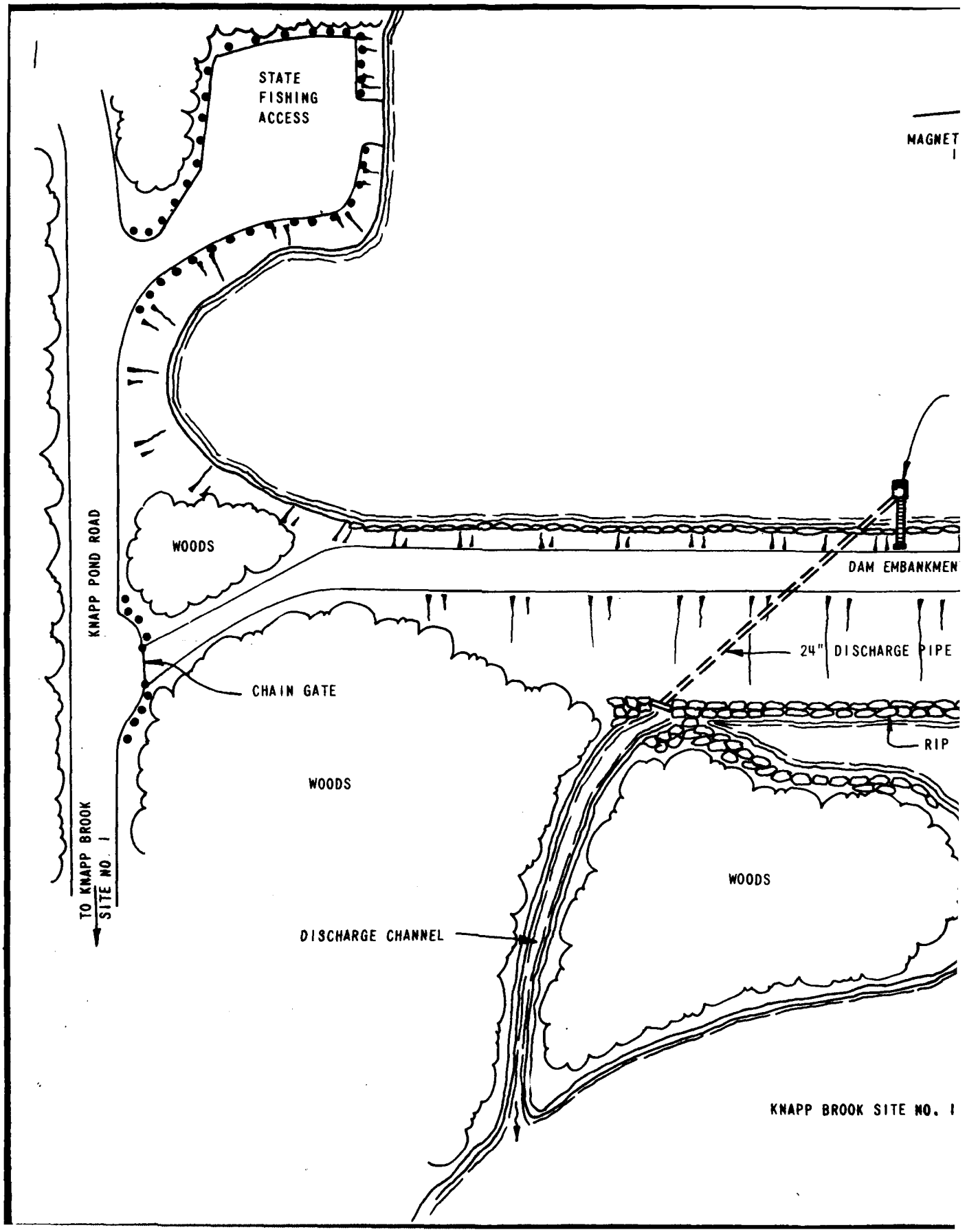
Date: January 7, 1974

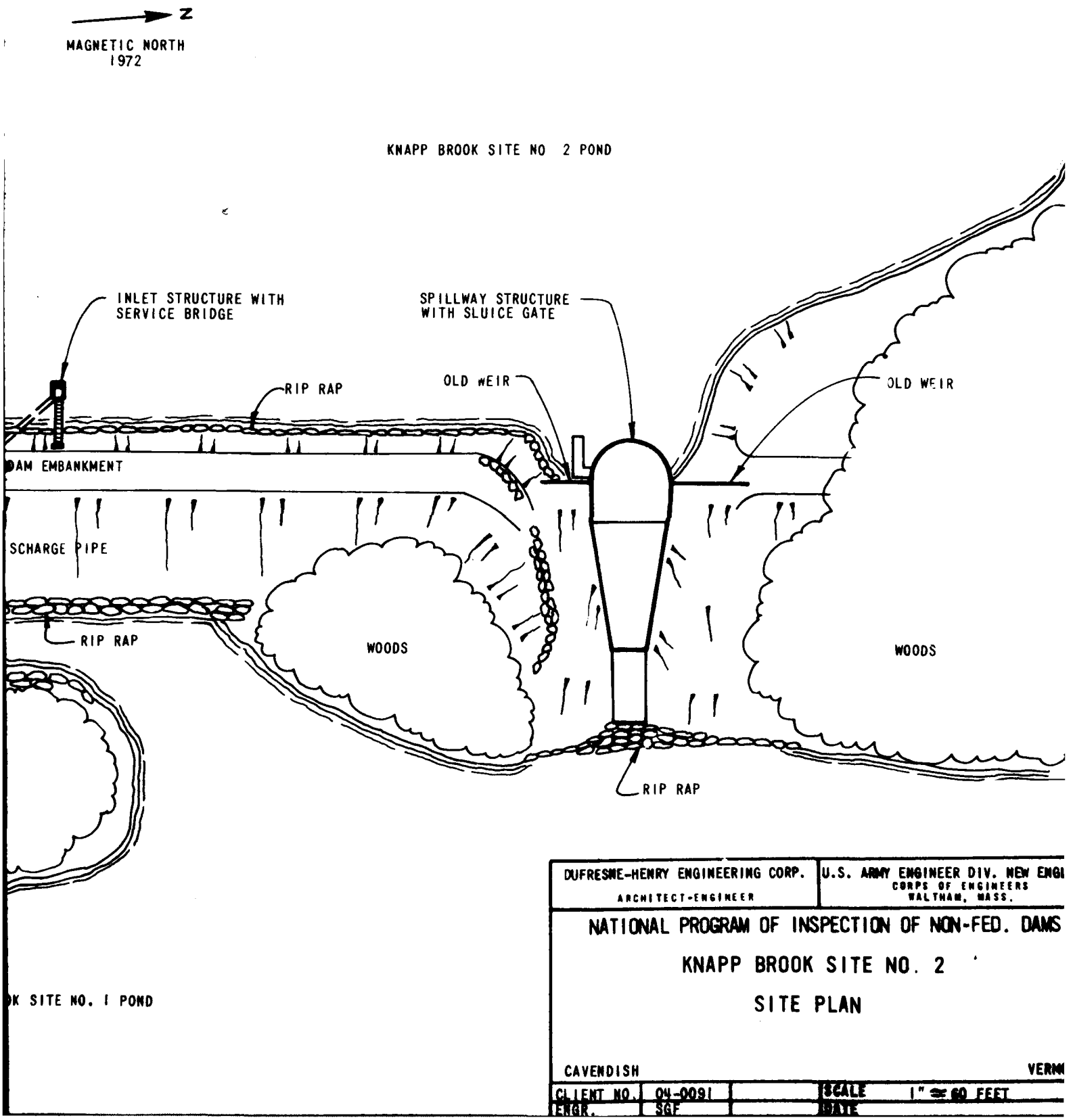
It has just come to my attention that we have an outstanding request from Will Irwin regarding the above captioned dams (copy attached). Here are our comments that Will asked for:

The damage at both dams during the flood of June 30, 1973, was in the emergency spillways. It consisted of severe erosion of the earth spillway, causing a partial failure to the spillway. This kind of partial failure becomes worse every time water flows over the emergency spillway. It is possible that the emergency spillway may not be utilized for several years, but on the other hand, it could be required to pass water at any time. The Fish & Game Department, at our request, has lowered the water level in both ponds so that the ponds are almost empty and have only nominal conservation pools at the present time.

It is very important that the emergency spillway be repaired so that complete failure would not occur. The Fish & Game Department has retained consultants to re-design the emergency spillways. The firm of Dufresne-Henry is doing the work at Knapp Pond Dam #2 and the firm of DuBois & King is doing the work at Kent Pond Dam. The design has been reviewed by our office and there is no substantial change to the purpose of the impoundments, although the emergency spillways will now be controlled by concrete and rock fill, as opposed to being an excavation and to original ground as they were previously. This is the only practical way of correcting the situation.

I do consider this as a significant alteration of a dam and I further consider it to be emergency work. Both projects are now under construction with the critical phases scheduled for completion prior to the spring runoff. The procedures provided by Chapter 43 should be followed for both of these projects. However, time is not available for these procedures due to the critical conditions remaining while the matter is being considered.


STATE
FISHING
ACCESS
MAGNET
KNAPP POND ROAD
WOODS
DAM EMBANKMEN
24" DISCHARGE PIPE
CHAIN GATE
RIP
WOODS
WOODS
TO KNAPP BROOK
SITE NO. 1
DISCHARGE CHANNEL
KNAPP BROOK SITE NO. 1



DUFRESNE-HENRY ENGINEERING CORP. ARCHITECT-ENGINEER	U.S. ARMY ENGINEER DIV. NEW ENGL CORPS OF ENGINEERS WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

KNAPP BROOK SITE NO. 2

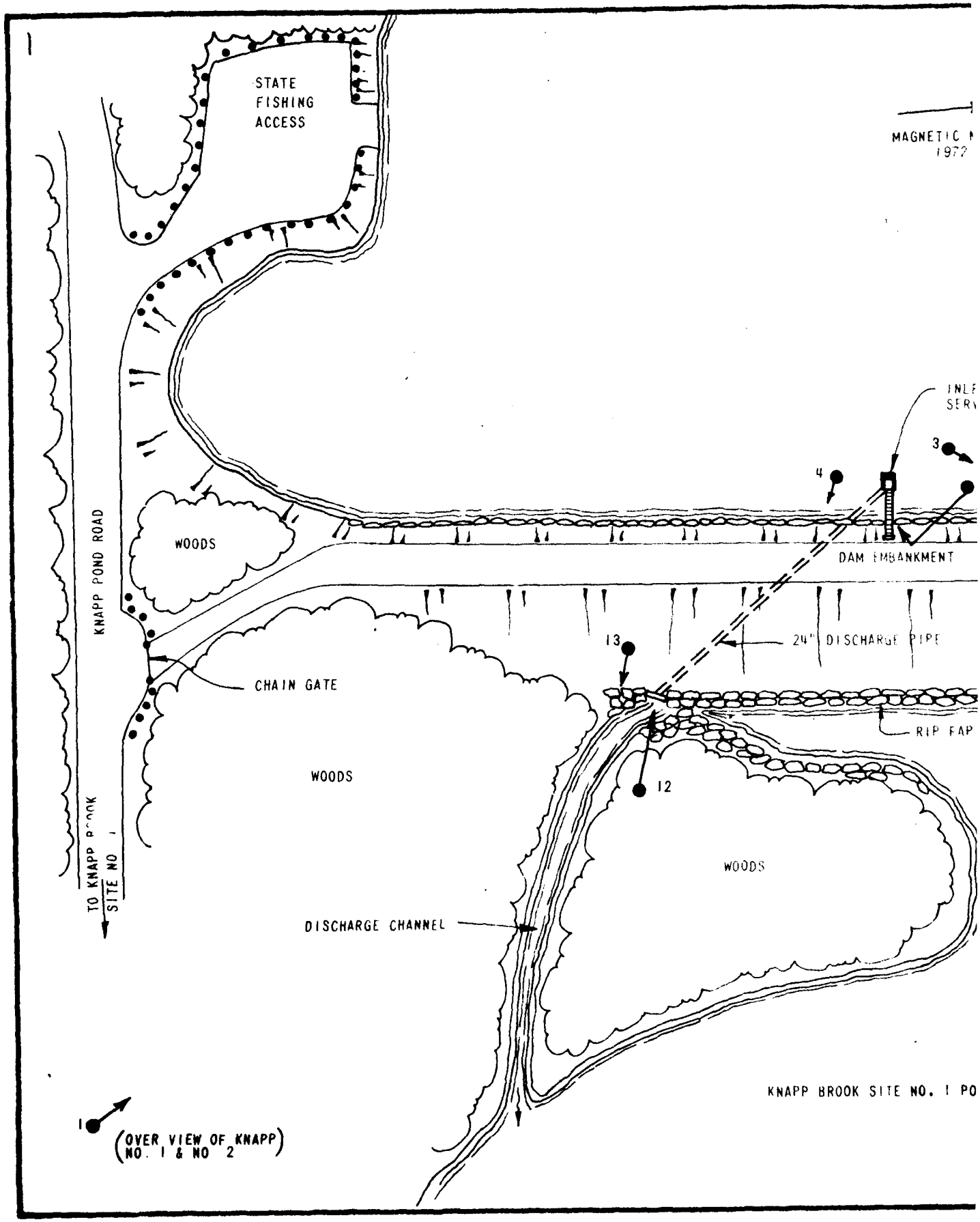
SITE PLAN

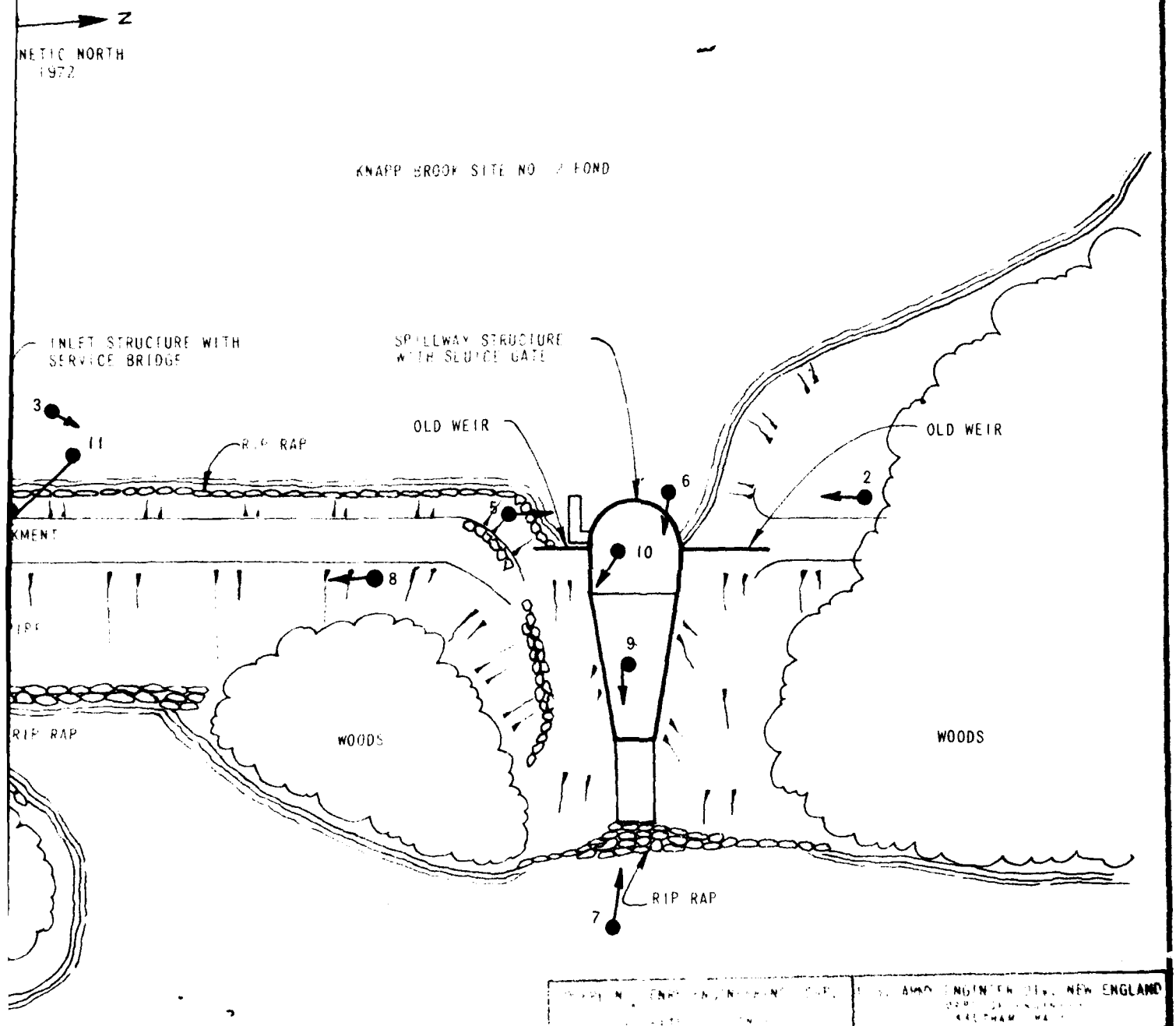
CAVENDISH VERM

CLIENT NO.	04-0091	SCALE	1" = 60 FEET
ENGR.	SGF	DATE	

APPENDIX C

PHOTOGRAPHS


STATE
FISHING
ACCESS
MAGNETIC N
1972
INLE
SER
3
4
WOODS
KNAPP POND ROAD
DAM EMBANKMENT
24" DISCHARGE PIPE
13
CHAIN GATE
RIP RAP
WOODS
12
WOODS
TO KNAPP BROOK
SITE NO 1
DISCHARGE CHANNEL
KNAPP BROOK SITE NO. 1 PO
1
(OVER VIEW OF KNAPP
NO. 1 & NO 2)



KEY

8 PHOTO INDEX AND DIRECTION

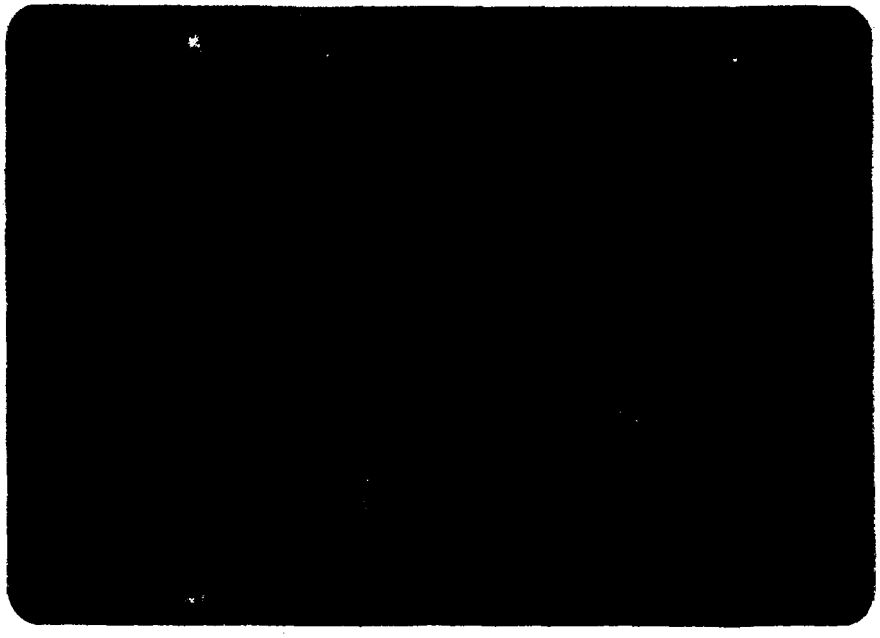
NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

KNAPP BROOK SITE NO. 2

PHOTOGRAPHIC LOCATION PLAN

CAVENDISH VERMONT

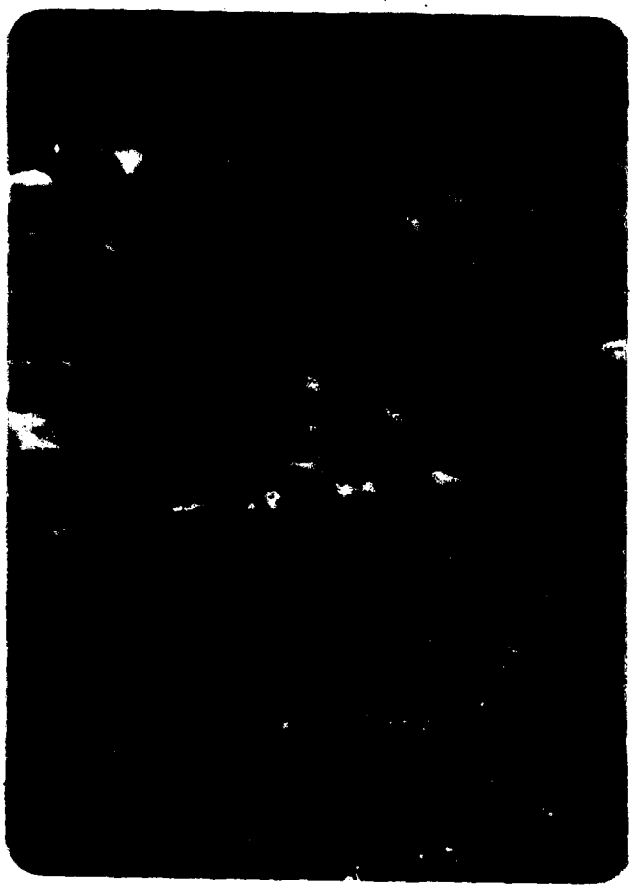
CLIENT NO	04-00911		SCALE 1" ≃ 60 FEET
ENGR	SGF		DATE



#1. OVERVIEW OF KNAPP BROOK SITES NO. 1 AND NO. 2. KNAPP BROOK SITE NO. 2 IS THE BODY OF WATER ON THE LEFT; THE DAM BETWEEN THE TWO PONDS IS KNAPP BROOK SITE NO. 2.

#2. EMERGENCY SPILLWAY IN FOREGROUND WITH OUTLET STRUCTURE AND DAM EMBANKMENT IN BACKGROUND.

#3. UPSTREAM LEFT FACE OF DAM.



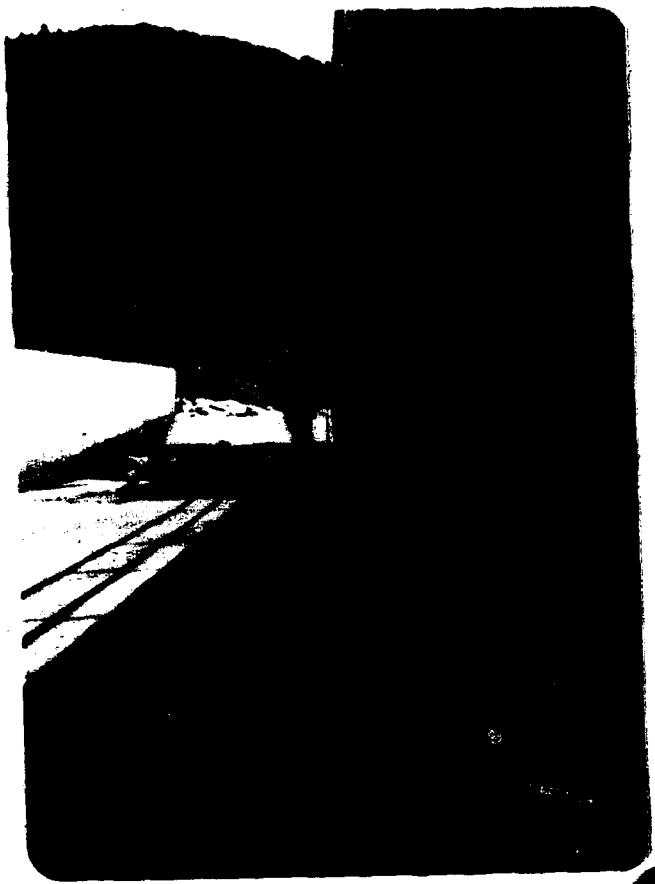
#4. CLOSE-UP OF RIP-RAP ON UPSTREAM RIGHT SIDE OF OUTLET STRUCTURE. NOTE MISSING RIPRAP.

#5. EMERGENCY SPILLWAY WITH APPROACH CHANNEL TO SLUICE GATE.

#6. CHUTE AT EMERGENCY SPILLWAY. KNAPP BROOK SITE NO. 1 POND AT OUTLET.

#7. CHUTE INTO KNAPP BROOK SITE NO. 1 POND.

#8. DOWNSTREAM SLOPE OF DAM.

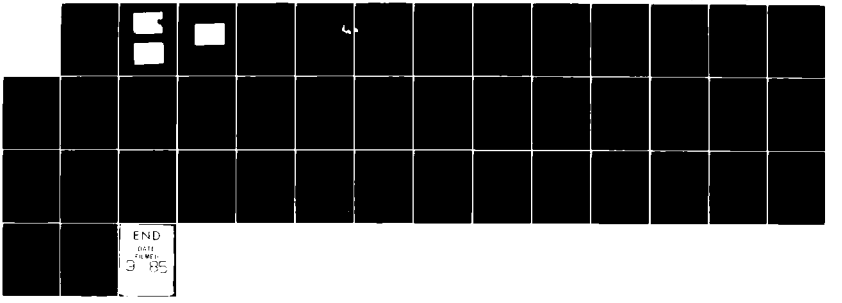


#9. RIGHT TRAINING WALL OF CHUTE SHOWING MAXIMUM DEFLECTION.

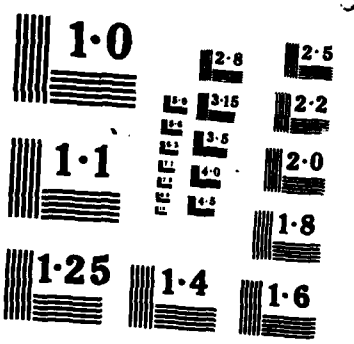
#10. RIGHT TRAINING WALL OF CHUTE, SHOWING SEPARATION AT CONSTRUCTION JOINT.

AD-A157 519 NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS KNAPP BROOK SITE NUMB..(U) CORPS OF ENGINEERS WALTHAM MA NEW ENGLAND DIV MAR 80 2/2

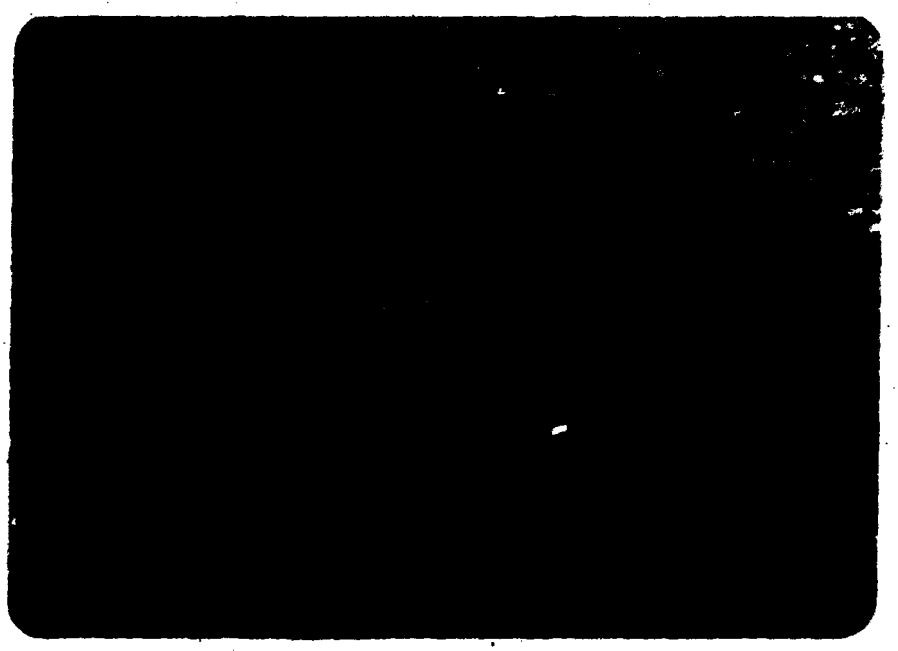
UNCLASSIFIED F/G 13/13 NL



END
DATE FILMED
3 85


1·0
2·8
2·5
3·15
2·2
1·1
3·5
2·0
1·8
1·25
1·4
1·6

#11. SERVICE BRIDGE. NOTE SUPPORT POST BROKEN BY ICE PRESSURE.



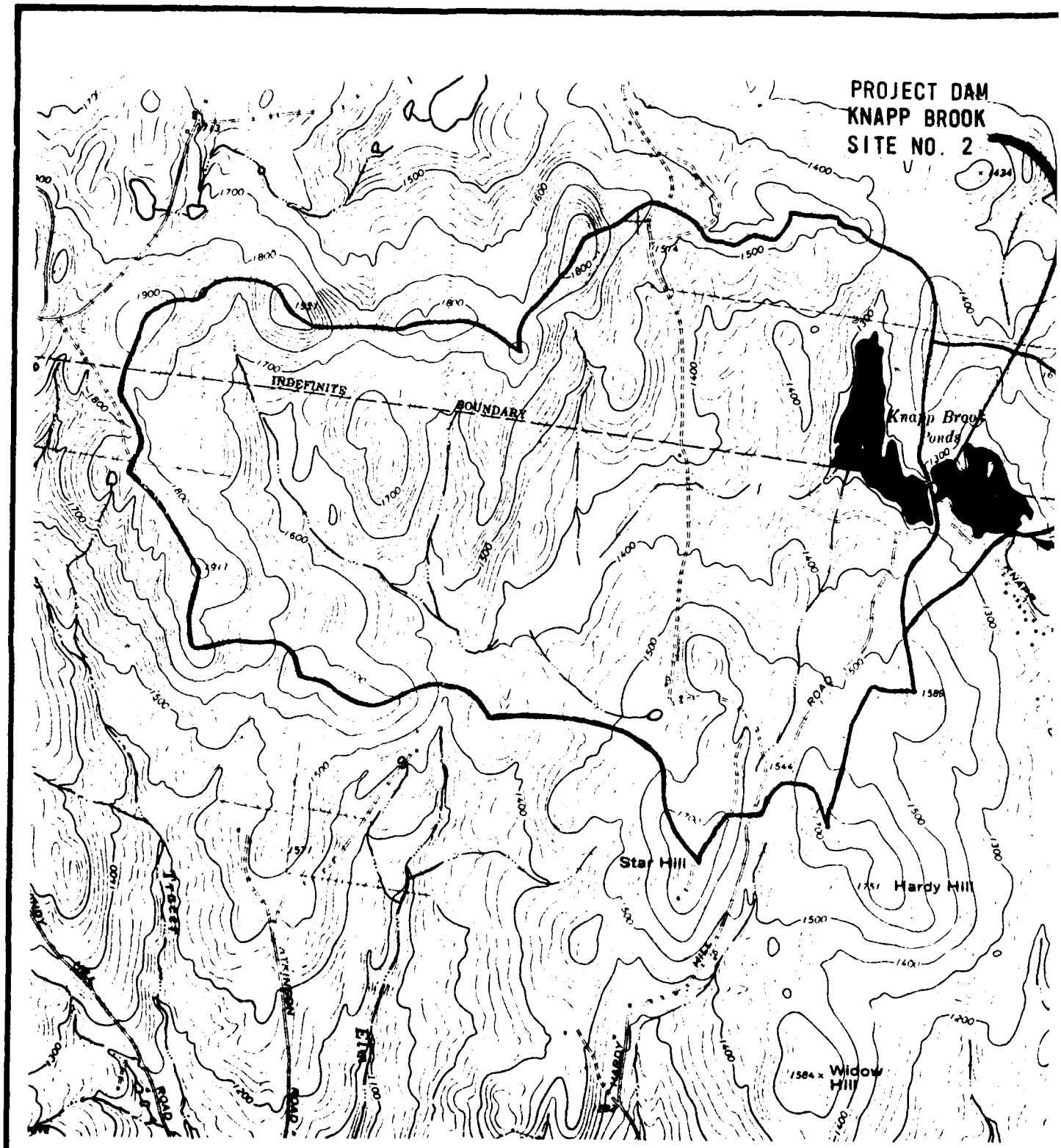
#12. DISCHARGE PIPE FROM OUTLET STRUCTURE.

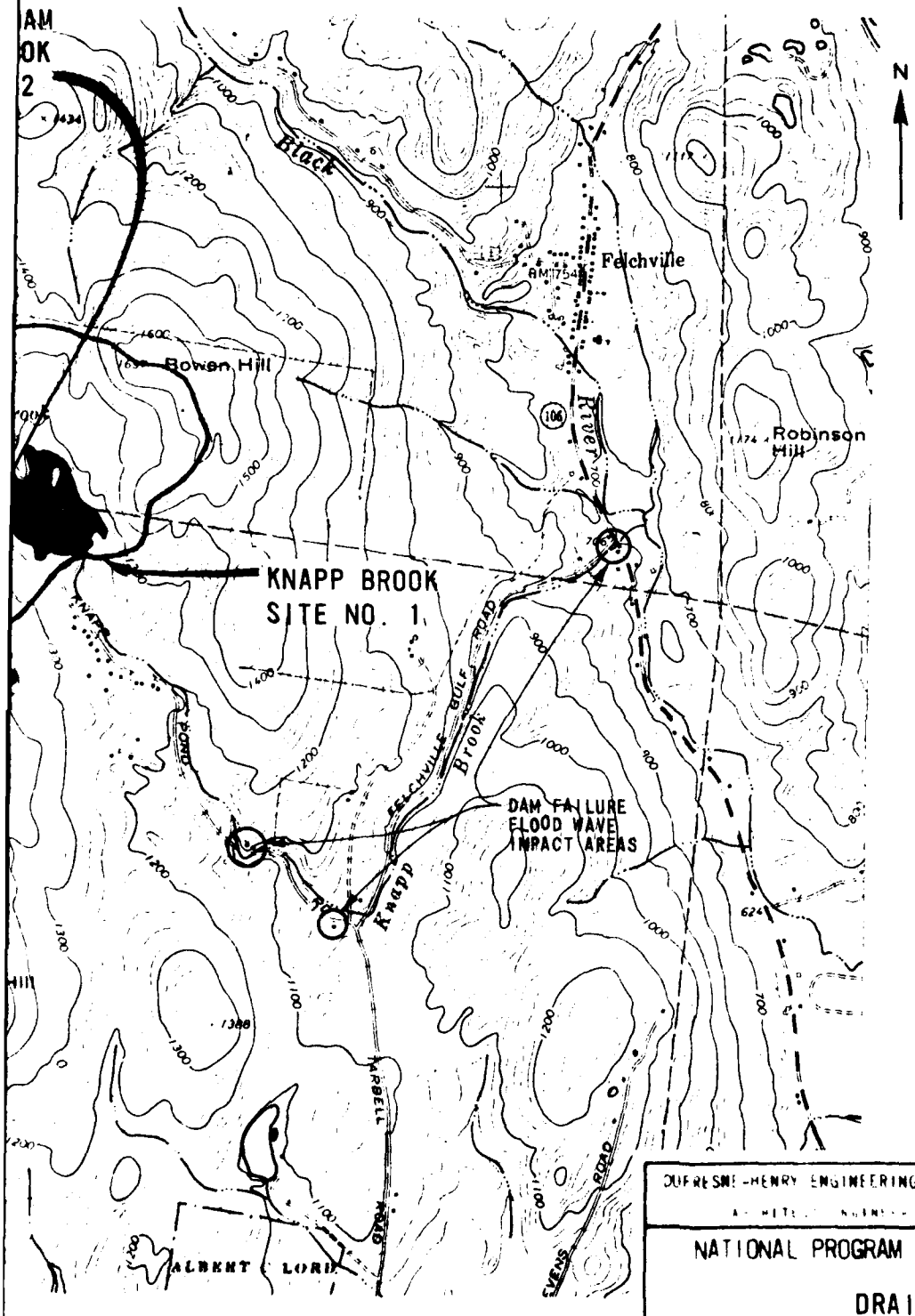
#13. EROSION IN OUTLET CHANNEL FROM OUTLET STRUCTURE AND APPARENT SEEPAGE FROM BANK.

APPENDIX D

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

CONTENTS


PROJECT DAM
KNAPP BROOK
SITE NO. 2
INDEFINITE
BOUNDARY
Knapp Brook
Ponds
Star Hill
Hardy Hill
Widow
Hill
ROAD
ATKINSON
HARDY
1544
1584



SOURCE OF MAP

U S GEOLOGICAL SURVEY
CAVENDISH VERMONT
QUADRANGLE 1972
1:24000 SERIES V813

DUFRESNE-HENRY ENGINEERING CORP.	U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

DRAINAGE AREA

KNAPP BROOK SITE NO. 2

CLIENT NO.	04-0091		SCALE 1"=2000'
ENGINEER	SGE		DATE

DUFRESNE-HENRY ENGINEERING CORPORATION

BY S.G. FARNSWORTH SUBJECT KNAPP BROOK #2 SHEET NO.
DATE 3-22-79 HYDROLOGY COMPUTATIONS FOR HEC-1 JOB NO. 09-0091

DRAINAGE AREA:*

$20.15\ IN^2 * (2000\ FT/IN)^2 * (1\ ACRE/43{,}560\ SF) = 1850\ ACRES = 2.89\ SQ.MI.$

POND AREA:*

$0.44\ IN^2 * (2000\ FT/IN)^2 * (1\ ACRE/43{,}560\ SF) = 40.4\ ACRE = .063\ SQ.MI.$

LENGTH OF MAIN STREAM FROM POND TO HEADWATERS:

$6.95\ IN * 2000\ FT/IN = 13{,}900\ FEET = 2.63\ MILES$

ELEV. @ 85%:

$15\% * 13{,}900\ FEET \div 2000\ FT/IN = 1.04\ IN \Rightarrow 1600\ ELEV.$

ELEV @ 10%:

$10\% * 13{,}900\ FEET \div 2000\ FT/IN = 0.70\ IN \Rightarrow 1330\ ELEV.$

AVERAGE STREAM SLOPE:

$$S = \frac{1600\ FEET - 1330\ FEET}{75\%\ \ 2.63\ MILES} = 137\ FT/MILE$$

PRECIPITATION INDEXES:

10 SQ MI	PMS	17.5
	R6	111%
	R12	123%
	R24	133%

IMPERVIOUS AREA:

$$\frac{.044}{20.15} = .022$$

$$T_p = 2.2\left[\frac{(L)(L_c)}{(\sqrt{S})}\right]^{.37}$$

L = STREAM LENGTH (MILES)
L_c = 0.6 L
S = AVE SLOPE FT/MI.

$$T_p = 2.2\left[\frac{(2.63)(66)(2.63)}{\sqrt{137}}\right]^{.37} = 1.50$$

* REFERENCE - U.S.G.S SHEET, CAVENDISH, VT., 7½ MINUTE, 1972, 1" = 2000 FEET.

DUFRESNE-HENRY ENGINEERING CORPORATION

BY S.G. FARNSWORTH SUBJECT KNAPP BROOK #2 SHEET NO.
DATE 3-22-79 HYDROLOGY DATA. JOB NO. 09-0091

SOIL CLASSIFICATION:

FROM THE WINDSOR COUNTY, VERMONT, GENERAL SOIL MAP, U.S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE.

APPROXIMATLY 50% OF THE AREA IS COLERED WITH WOODSTOCK - COLRAIN (C-B) & 50% OF THE AREA IS COVERED WITH COLRAIN OF THE COLRAIN - BUCKLAND ASSOCIATION (B-C).

USING GROUP C, LAND USE WOODED (FAIR)
CN # 73

INITIAL RAINFALL LOSS FROM SCS TABLE 10.1 I_a (IN/hr)

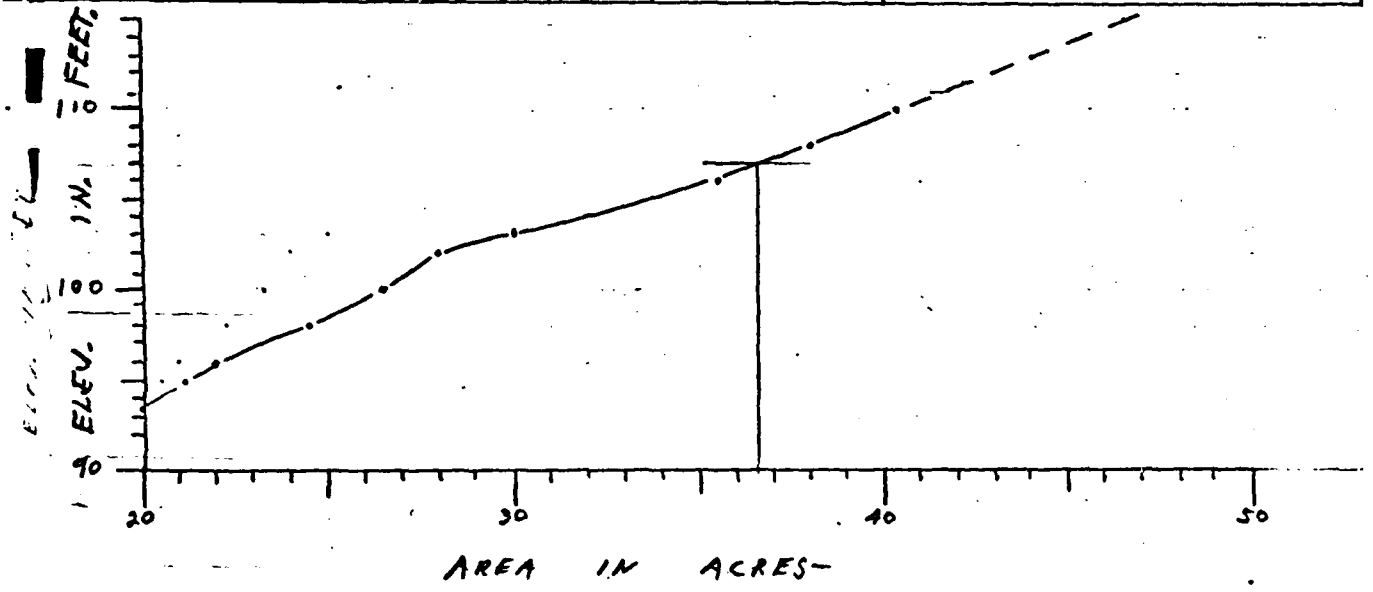
$I_a = 0.30$ = STRTL

CNSTL ⇒ .12 IN/hr.

DUFRESNE-HENRY ENGINEERING CORPORATION

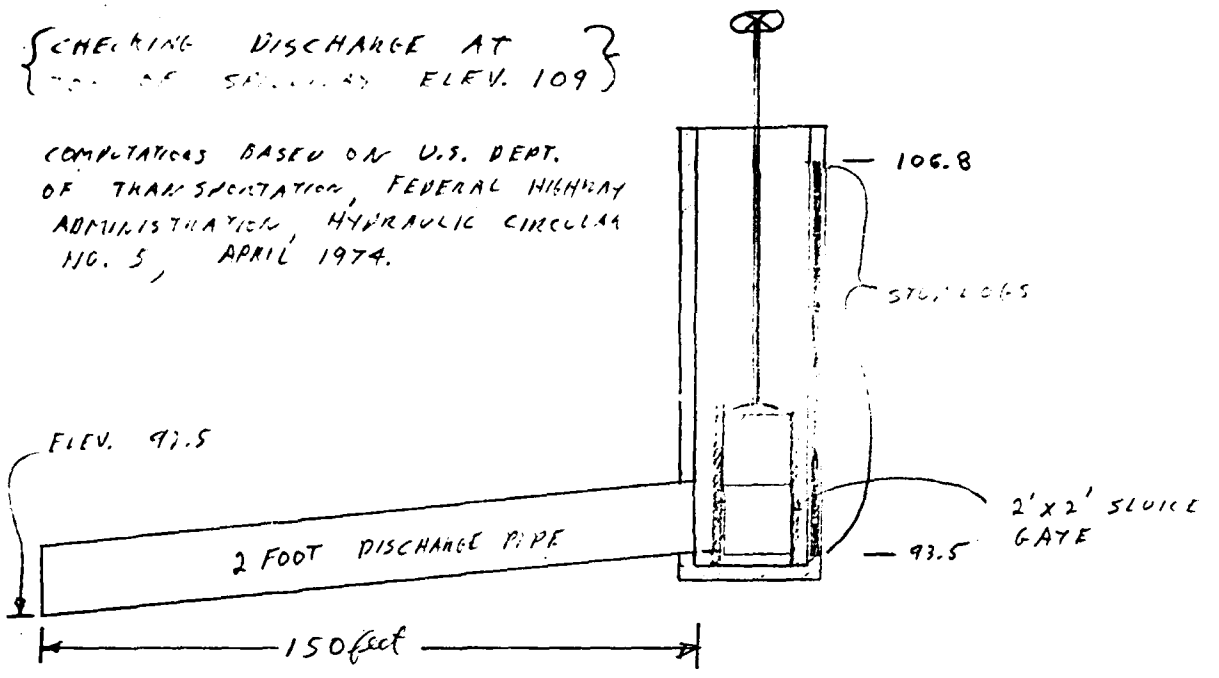
BY S.G. FARNSWORTH SUBJECT KNAPP BASIN SITE #2 SHEET NO
DATE 5-24-79 STORAGE JOB NO. 79-0691

ELEVATION (FEET)	SURFACE AREA (ACRES)		STORAGE TO EXISTING STREAM BED AT DAM (AC-FT)	REMARKS
115	46.5		700	NOTE 1. FROM PAST DH STUDY
114	45.4		654	
113	44.0	NOTE 3	610 → TOP OF DAM	NOTE 2. FROM PAST D-H STUDY CONTOURS OF KNAPP #2
112	43.0		566	
111	41.7		524	
110	40.3		483	NOTE 3. TAKEN FROM GRAPH AT BOTTOM OF PAGE.
108	38.0	NOTE 2	405	
106	35.5		331 → TOP OF SPILLWAY (67)	
104	32.0	NOTE 3	264	
103	30.0		232.8	
102	28.0		203.8	
100	26.6	NOTE 1	149.2	
98	24.5		98.1	
96	22		51.6	
95	21.1		30.1	
93.5	19		0	



{CHECKING DISCHARGE AT [illegible] OF SPILLWAY ELEV. 109}

COMPUTATIONS BASED ON U.S. DEPT. OF TRANSPORTATION, FEDERAL HIGHWAY ADMINISTRATION, HYDRAULIC CIRCULAR NO. 5, APRIL 1974.



INLET CHARTS

$H = 109 - 93.5 = 15.5$ feet

FOR 24 INCH C.M. PIPE, $Hw/d = \frac{15.5}{2} = 7.75$, $Q = 60$ CFS

OUTLET CONTROL

$$H = 1 + Ke + \frac{29\, n^2 L}{R^{4/3}} \left[\frac{(Q/A)^2}{2g}\right]$$

$Hw = H + h_o - L_s \Rightarrow 15.5 \leq H + 2.0^{\text{MAX.}} - 1.0 \Rightarrow H = 14.5$ feet

$$14.5 = \left[1 + .5 + \frac{29(.025)^2 150\text{ft}}{(0.5)^{1.333}}\right] \frac{(Q/3.142)^2}{64.4}$$

$14.5 = .13\ Q^2 \Rightarrow Q = \sqrt{14.5/.13} \approx 11$ CFS

OUTLET CONTROL

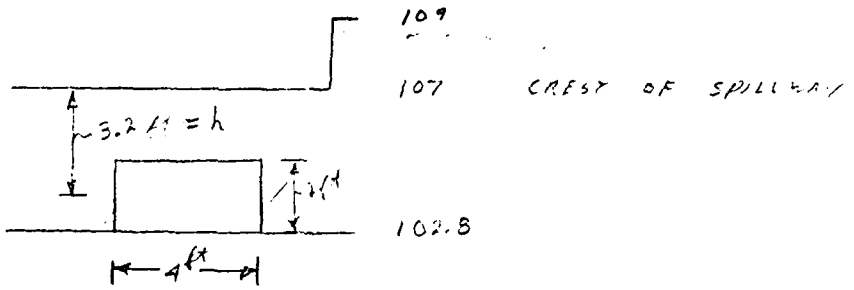
11 CFS VS 676 CFS

ONLY 1.6% FLOW, NOT INCLUDING IN HYDRAULICS AS THIS STRUCTURE CAN VERY EASY BE PLUGGED AND AMOUNTS TO A VERY LOW PERCENTAGE OF THE TOTAL FLOW ANY WAY.

DUFRESNE-HENRY ENGINEERING CORPORATION

BY S.L. FARNSWORTH SUBJECT KNAPP BROOK SITE NO. 2 SHEET NO. ____ OF ____
DATE 5-16-79 SPILLWAY SLUICE GATE DISCHARGE JOB NO. ____

DISCHARGE OF SPILLWAY SLUICE GATE AT TOP OF SPILLWAY



ORFICE FLOW

@ SPILLWAY $Q = CA\sqrt{2gh} = .65\,(2' \times 4')\sqrt{2g\,(3.2\,ft)} = 75\,cfs$

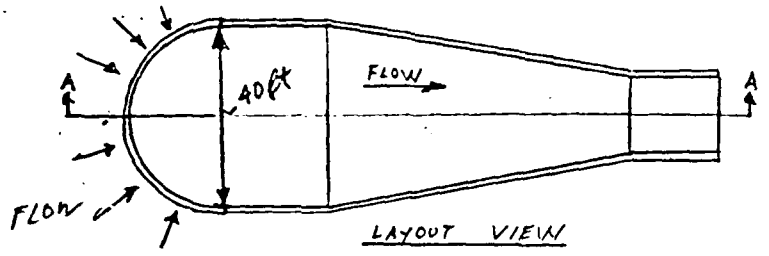
@ TOP OF SPILLWAY $Q = 41.7\sqrt{5.2} = 95\,cfs$

@ TOP OF DAM $Q = 41.7\sqrt{9.2} = 126\,cfs$

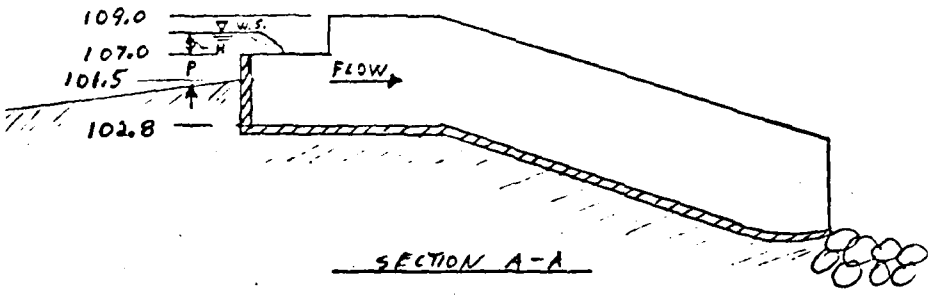
BY S.G. FARNSWORTH DATE 5-16-79 SUBJECT KNAPP BROOK SITE NO. 2 SPILLWAY HYDRAULICS SHEET NO. JOB NO. 04-0091

SPILLWAY HYDRAULICS:

ELEVATIONS, LOCAL DATUM.



LAYOUT VIEW



SECTION A-A

$L = \pi \, DIA/2 = \pi \, 40^{ft}/2 = 62.8'$

$Q = Ce \, L \, H^{3/2}$

ELEVATION (ft.)	H (ft)	H/P *	Ce **	Q
107	0	0	0	0 CFS
107.5	.5	.33	3.35	74 CFS
108.0	1.0	.67	3.45	217
108.5	1.5	1.0	3.64	420
109.0	2.0	1.33	3.75	666
109.5	2.5	1.67	3.88	963
110	3.0	2.0	4.02	1312
111	4.0	2.4	4.16	2090
112	5.0	3.3	4.59	3188
113	6.0	4.0	4.82	4449
113.5	6.5	4.33	4.95	5152
114	7.0	4.64	5.08	5908
115.5	8.0	5.33	5.35	7602
116	9.0	MAX FOR 5.67	5.48	9292

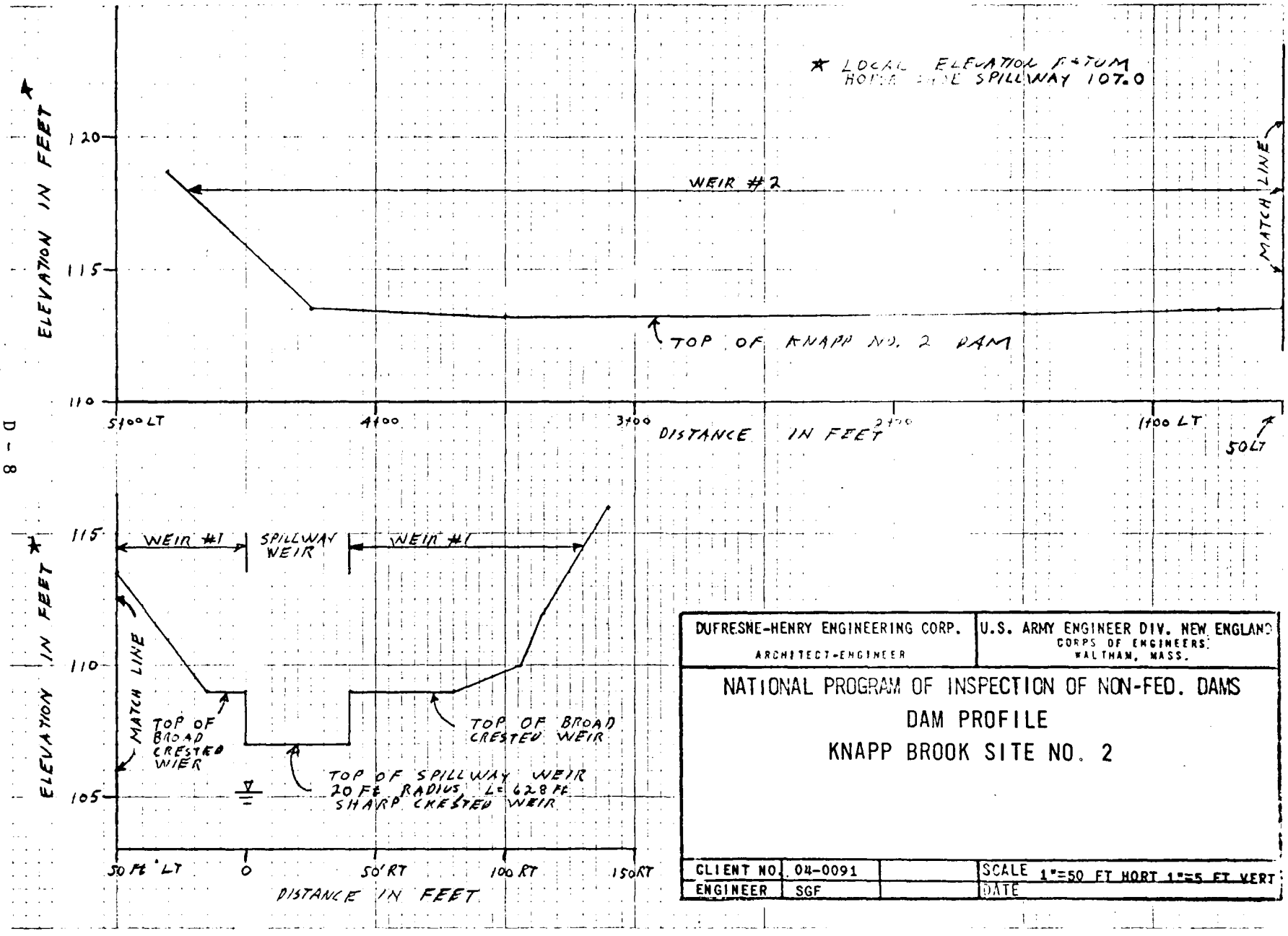
* REFERANCE - KING & BRATER, HANDBOOK OF HYDRAULICS, SIX EDITION, PAGE 5-14.

Ce, (.33 → 2.4) H/P FIG. 5.3(b)

FOR Ce WHEN H/P IS BETWEEN 2.4 & 5.67

$Ce = 3.22 + .4 \frac{H}{P}$

[MAX. PAO. FLOOD. = 2.89 sm * 2400 CFS/SM = 6936 CFS ± 1/2 3500 ±]



DUFRESNE-HENRY ENGINEERING CORP. ARCHITECT-ENGINEER	U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS. WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

DAM PROFILE

KNAPP BROOK SITE NO. 2

CLIENT NO.	04-0091		SCALE 1"=50 FT HORT 1"=5 FT VERT
ENGINEER	SGF		DATE

DUFRESNE-HENRY ENGINEERING CORPORATION

BY S.C. FARNSWORTH SUBJECT KNAPP CREEK SITE NO. 1 SHEET NO. ____

DATE 5-23-79 STAGE STORAGE - DISCHARGE TABLE JOB NO. 09-0092

ELEVATION (Ft)	STORAGE AC-ft	DISCHARGE (CFS)		REMARKS
		BRUSH REMOVED FROM SPILLWAY	BRUSH COVERED SPILLWAY	
91.6	166	0	0	INVERT OF DROP STRUCTURE.
92.0	179	28	28	
92.6	192	118	118	INVERT OF SPILLWAY WEIR. (START WEIR HEAD)
93.0	205	277	236	
94.0	231	898	589	
95.0	260	1,707	989	
96.0	292	2,802 *	1549 *	TOP OF EARTH DAM
97.0	325	4,991	3011	
98.0	357	9,182	5669	
99.0	391	14,813	10,081	
100.0	427	22,153	15,933	

PUT

* $= \frac{1509}{2802} * 100\% = 54\%$, BECAUSE OF THE BRUSH IN THE SPILLWAY, THE CAPACITY OF THE SPILLWAY DISCHARGE AT TOP OF DAM IS REDUCED BY 46% ±. STRONGLY RECCOMEND THE REMOVE OF BRUSH FROM THE SPILLWAY AND BEAVER DAMS FROM THE SPILLWAYS DISCHARGE CHANNEL.

DUFRESNE-HENRY ENGINEERING CORPORATION

BY S.G. FARNSWORTH SUBJECT KNAPP BROOK SITE NO. 1 SHEET NO.
DATE 5-23-79 SPILLWAY HYDRAULICS WITH BRUSH JOB NO. 09-0092

KNAPP BROOK SITE NO. 1 SPILLWAY IS COMPLETLY COVERED WITH 1" - 2" BRUSH STANDING 8' HIGH. ESTIMATED N = 0.12. THE FOLLOW HYDRAULICS IS BASED ON EXISTING CONDITIONS, ASSUMING NORMAL FLOW AT THE RESTRICTED SECTION AND BRUSH IN CHANNEL.

ELEV. (FT)	AREA (S.F.)	W.P. (FT.)	DISCHARGE (CFS)
93.0	54	112	43 CFS
93.5	113	118	143
94.0	172	124	278
94.5	237	130	367
95.0	302	136	668
95.5	373	142	922
96.0	444	148	1200
96.5	523	158	1509
97.0	602	168	1830
97.5	706	232	1926
98.0	809	240	2362
98.5	935	249	2934
99.0	1061	257	3546
99.5	1194	266	4220
100.0	1328	274	4940 CFS

$S = 4\text{ft}/370\text{ft} = .011$

$Q = \frac{1.486}{n} A R^{2/3} S^{1/2}$

$Q = \frac{1.486}{0.12} (.011)^{1/2} A R^{2/3}$

$Q = 1.30\ A R^{2/3}$

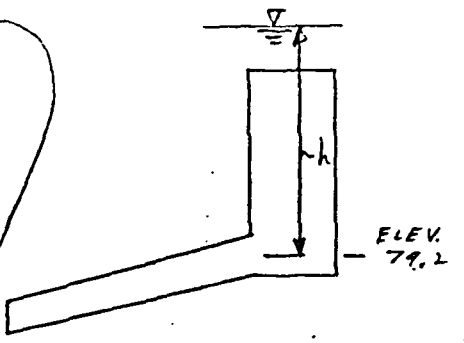
$Q = 1.30\ A \left(\frac{A}{WP}\right)^{2/3}$

DROP STRUCTURE

CHECKING FOR MAXIMUM DISCHARGE OF 48" R.C.P

$$Q = CA\sqrt{2gh} = (.8)(12.6\,SF)\sqrt{2g\,h} = 80.8\sqrt{h}$$

ELEVATION	h (Ft)	Q (CFS)
92	12.8	287 CFS
92.5	13.3	295
93.0	13.8	300
93.5	14.3	306
94.0	14.8	311
94.5	15.3	316
95.0	15.8	321
95.5	16.3	326
96.0	16.8	331
96.5	17.3	336
97.0	17.8	341
97.5	18.3	346
98.0	18.8	350
98.5	19.3	355
99.0	19.8	360
100.0	20.8	369



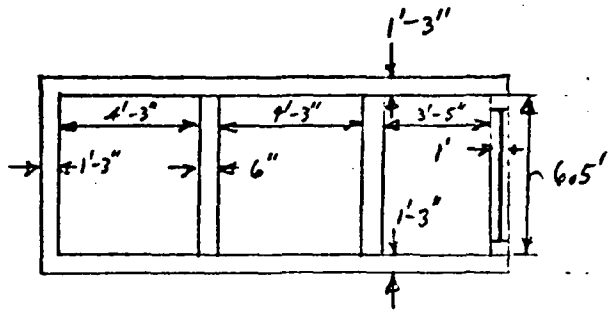
VOID UNDER DROP INLET CONTROL.

UNDER 48" ORIFICE CONTROL, SEE SHEET # 1

TOP OF SPILLWAY AT 92.6
TOP OF DAM AT 95.8

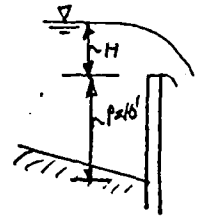
BY S.G. FARNSWORTH SUBJECT KNAPP BROOK SITE #1 SHEET NO.
DATE 4-24-79 HYDRAULICS JOB NO. 04-0092

STAGE DISCHARGE OF DROP STRUCTURE:



LENGTH OF WEIR (L)
(4.25+4.25+3.42+6.5) x 2 = 36.8
USING 36 FT

$Q = C_e L H^{3/2}$

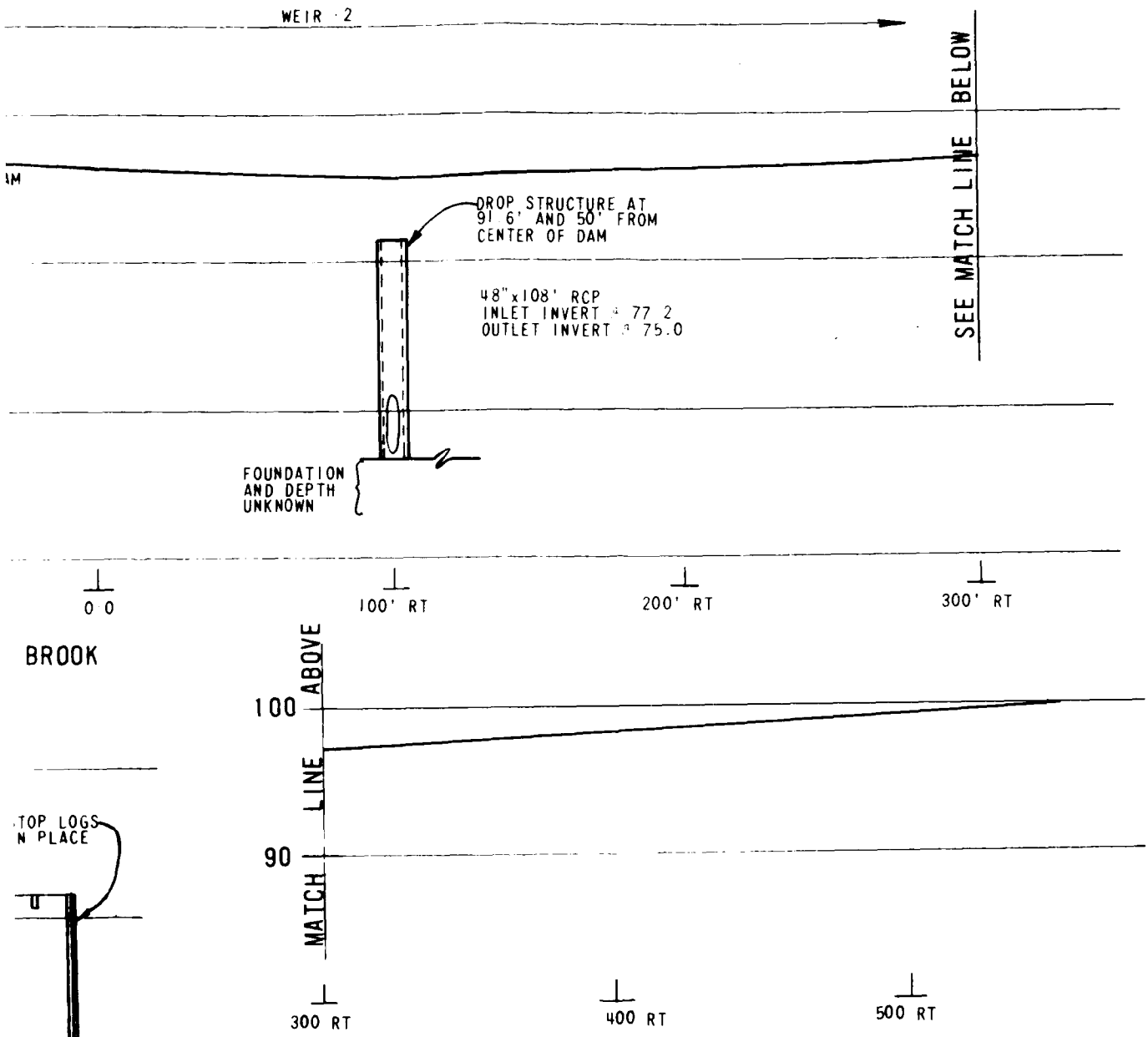


ELEVATION	H (FT)	H/P	C_e	Q CFS
91.6	0	0	0 CFS	0 CFS
92.0	0.4	.04	3.1	28
92.5	0.9	.09	3.21	99
92.6	1.	1.0	3.21	118
93.0	1.4	.14	3.23	193
93.5	1.9	.19	330	311
94.0	2.4	.24	3.31	443
94.5	2.9	.29	3.35	596
95.0	3.4	.34	3.35	756
95.5	3.9	.39	3.39	940
96.0	4.4	.44	3.41	1133
96.5	4.9	.49	3.42	1335
97.0	5.4	.54	3.44	1554
97.5	5.9	.59	3.46	1785
98.0	6.4	.64	3.48	2028

CHECK FOR PIPE MAX DISCHARGE

CONTROLED BY 48" ORIFICE SEE SHEET #2

CONTINUE ON NEXT SHEET



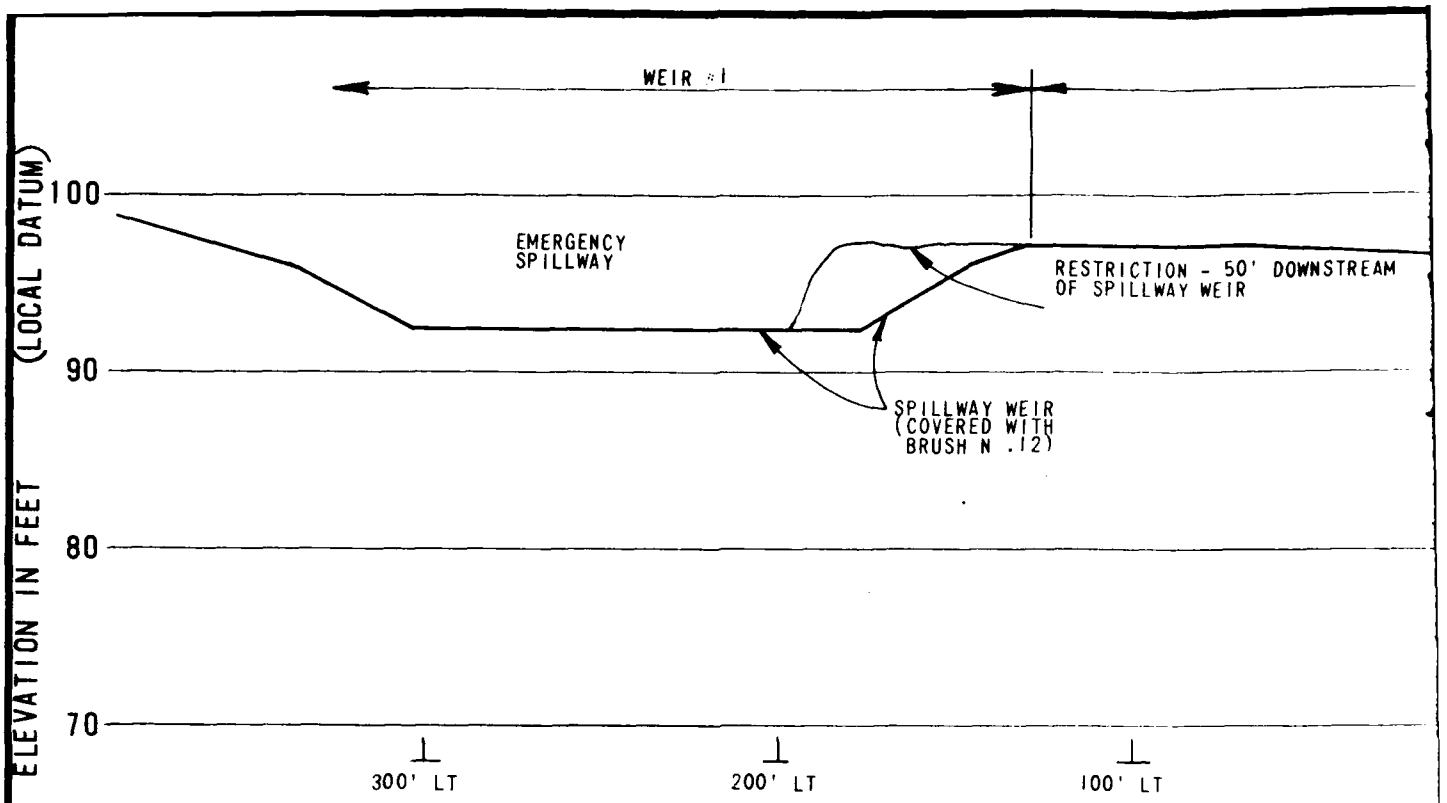
DUFRESNE-HENRY ENGINEERING CORP.	U.S. ARMY ENGINEER DIV. NEW ENGLAND

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

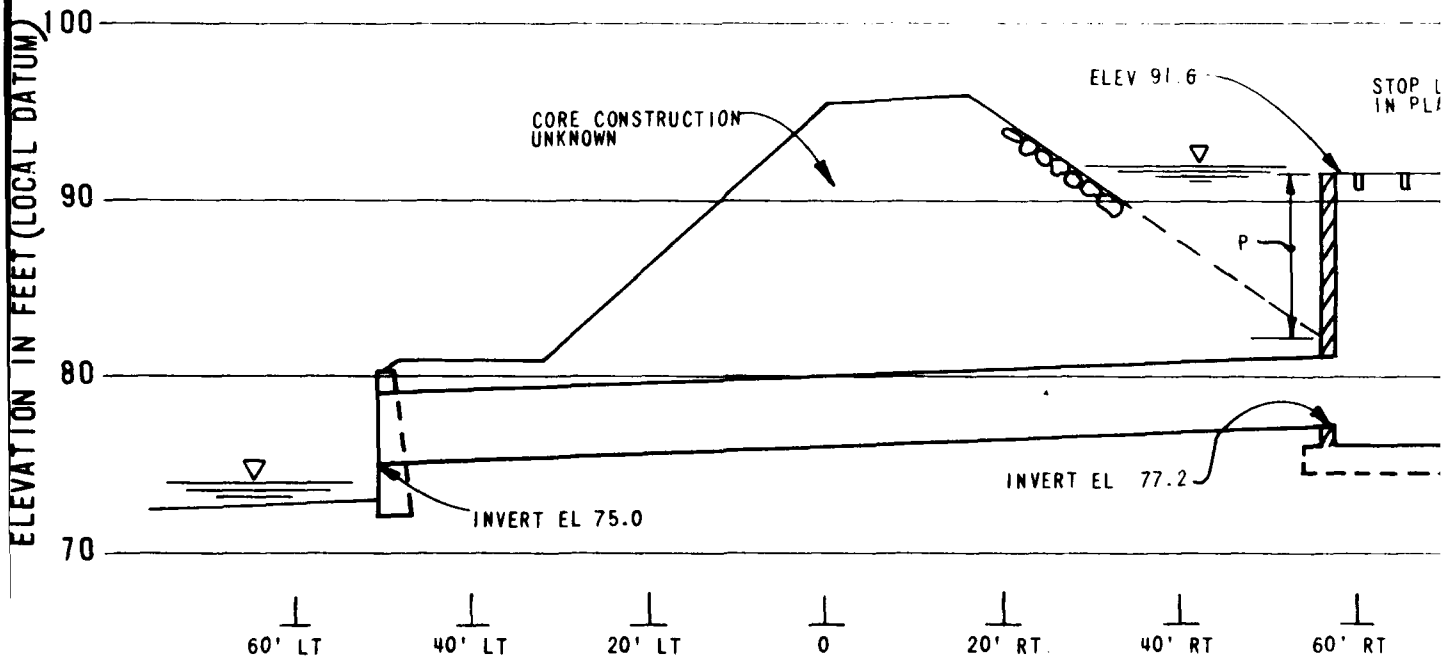
DAM PROFILE & CROSS SECTION

KNAPP BROOK SITE NO. 1

CLIENT NO	04-0092	SCALE	AS NOTED
ENGINEER	SGF	DATE	MARCH 1980



PROFILE OF KNAPP BR
SITE #1



SECTION THRU DAM

DUFRESNE-HENRY ENGINEERING CORPORATION

BY S.G. FARNSWORTH SUBJECT KNAPP SITE NO. 1 SHEET NO. ___
DATE 5-22-79 STAGE - STORAGE CURVE JOB NO. 04-0092

USING FISH & GAME CONTOUR MAP OF KNAPP NO. 1 *

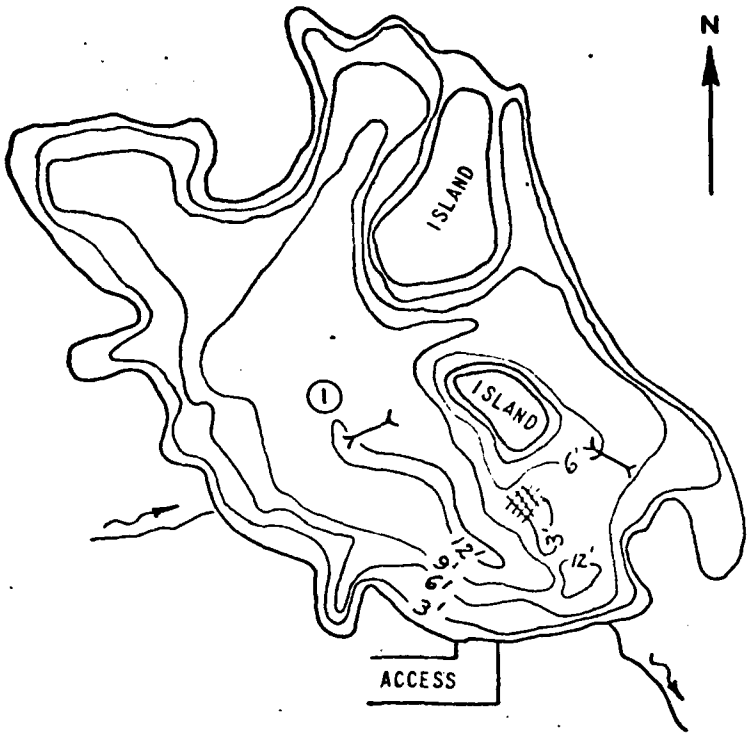
ASSUMING ZERO DEPTH AS TOP OF DROP STRUCTURE: {ELEVATION 96}

DEPTH	ELEVATION	AREA		ΔH	VOL (AC-FT)	Σ VOL (AC-FT)
		IN^2	ACRES			
-12	79.6	0.18	0.7		0	0
				3		
-9	82.6	1.75	6.4		10.7	10.7
				3		
-6	85.6	4.03	14.8		31.8	42.5
				3		
-3	88.6	5.70	20.9		53.6	96.0
				3		
0	91.6	6.98	25.6**		69.8	166
				1.0		
	92.6	—	27		26.3	192
				1.4		
	94	—	29		39.2	231
				2		
	96	—	31.2		60.2	292
				2		
	98	—	34.2		65.4	357
				2		
	100	—	35.8		70.0	427
				2		
	102	—	38***		73.8	501
				2		
	104	—	40		78.0	579

* INCORRECT SCALE ON MAP, 1" = 400 FT & NOT 200 FT
∴ $1\ IN^2 = (400\ FT/IN)^2 / 43{,}560\ SF/AC = 3.67\ AC/IN^2$

** AS COMPARED TO 25.7 AC FROM U.S.G.S SHEET
{$0.28\ IN^2 * (2000\ FT/IN)^2 * 1\ AC/43{,}560\ SF = 25.7\ AC$}

*** ESTIMATED USING U.S.G.S SHEET @ ELEV 1280



① CHEMICAL STATION

AQUATIC VEGETATION

GILLNET SETS

SOURCE OF MAP:

VERMONT FISH & GAME
MONTPELIER VERMONT
SCALE: 1" 400' APPROX

DUFRESNE-HENRY ENGINEERING CORP. ARCHITECT-ENGINEERS	U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

DEPTH CONTOUR MAP

KNAPP BROOK SITE NO. 1

CLIENT NO	04-0095		SCALE 1"=400'
ENGINEER	SGF		DATE

DAM INFORMATION:

LENGTH OF DAM 390'
HEIGHT OF DAM 21'
LENGTH OF DAM @ MID HEIGHT 200'

STORAGE AT TOP OF DAM 292 AC-FT.

DOWN STREAM HAZARD INFORMATION:
4 HOMES AT TOP OF STREAM BANKS; 0.8 MILES, 1.1 MILES & 2 @ 2.3 MILES

DRAINAGE AREA TO KNAPP #1 BELOW KNAPP #2: *

$$1.96\ IN^2 * (2000\ FT/IN)^2 * \frac{1\ SQ.MI/640\ AC * 1\ AC/43560\ SF}{(.1435\ SQ.MI/IN^2)} = 0.28\ SQ.MI.$$

TOTAL DRAINAGE AREA TO KNAPP #1

$$(1.96 + 20.15\ IN^2) * .1435\ SQ.MI./IN.^2 = 3.17\ SQ.MI.$$

KNAPP #1 SUB-AREA: * (AREA ONLY BETWEEN KNAPP #1 & KNAPP #2)

LENGTH OF STREAM, $0.80" * 2000\ FT/IN = 1600\ FT = 0.30$ MILES
ELEVATION @ .1L = 1285
ELEVATION @ .85L = 1400
SLOPE (S) = $(1400 - 1285)/(.75)(.30\ MILES) = 511\ FT/MILE$

$$T_p = 2.2\left[\frac{L_c L}{\sqrt{S}}\right]^{.37} = 2.2\left[\frac{.6(.3)(.3)}{\sqrt{511}}\right]^{.37} = 0.24\ HR$$

SOIL TYPE: WOODSTOCK - COLRAIN & COLRAIN - BUCKLAND
SOIL IS B-C ⇒ .18
$I_a = 0.30$

PRECIPITATION:

PMS	18.0
R6	111
R12	123
R24	133

IMPERVIOUS AREA (T10): $\frac{.30}{1.96} = .15$

* REFERANCE, , U.S.G.S. SHEET, CALENDISH, VT, 1:24000 1" = 2000 FT, 1972

DUFRESNE-HENRY ENGINEERING CORPORATION

BY S.G. FARNSWORTH SUBJECT KNAPP BROOK SITE NO. 2 SHEET NO. ____ OF ____
DATE 6-4-79 HAZARD CLASSIFICATION JOB NO. ____

FLOOD WAVE AT FIRST HOUSE, 4300 FEET DOWN STREAM OF KNAPP BROOK SITE NO. 1 DAM

ASSUMMING 5000 CFS AT FIRST HOME:

FOR 5000 CFS, AREA = 410 SF
FOR 5340 CFS, AREA = 430 SF
} AVE AREA = 420 SF

$Q_{P_2} = Q_{P_1}\left[1 - \frac{\text{VOLUME}}{\text{STORAGE}}\right] = 5340 \text{ CFS}\left[1 - \frac{420 \text{ SF} * 430 \text{ FT} = 4356}{527 \text{ AC-FT}}\right]$

Q_{P_2} = 4920 CFS VS 5000 CFS % ERROR 1.6

DEPTH OF FLOW OVER BANKS?

3.7 FEET (From D=)

DUFRESNE-HENRY ENGINEERING CORPORATION

BY S.G. FARNSWORTH SUBJECT KNAPP BROOK SITE NO. 2 SHEET NO. ____
DATE 6-1-79 HAZARD CLASSIFICATION JOB NO. 79-0091

SIZE CLASSIFICATION

HEIGHT OF DAM:

FROM STREAMBED TO TOP OF DAM (113.3 − 86 =) 27.3 FEET, BUT ONLY 21 FEET ABOVE NORMAL WATER SURFACE OF KNAPP BROOK SITE NO. 1.

COMPUTATIONS OF FLOODWAVE AND STORAGE INTO KNAPP BROOK SITE NO. 1 POND. ASSUMING THAT KNAPP BROOK SITE NO. 1 DAM DOES NOT BREAK AND THAT 2.2 FEET OF WATER WILL FLOW OVER THE CREST OF DAM. ALSO THAT SPILLWAY IS STILL COVERED WITH BRUSH!!

TOP OF KNAPP #1 + 2.2 FEET = 95.8 + 2.2 = 98.0 FEET
NORMAL WATER SURFACE 91.6 FEET
KNAPP #1 AVAILABLE STORAGE = 357 − 166 = 191 Ac-Ft.

FLOOD WAVE FROM KNAPP #2

HEIGHT = 113.3 − 98.0 = 15.3 FEET

$$Q_p = 8/27\ W_0 \sqrt{g}\ y_0^{3/2} = 8/27 (.4)(205)\sqrt{g}\ (15.3)^{3/2} = 8250 \text{ cfs}$$

STORAGE BEHIND KNAPP #2 ABOVE 97.3

623 − 98 = 525 Ac-Ft

$$Q_{P_2} = 8250 \text{ cfs} \left[1 - \frac{191}{525}\right] \simeq 5250 \text{ cfs} \quad \text{vs} \quad 5670 \text{ cfs}$$

% ERROR 7.4%

FROM STAGE - DISCHARGE CURVE OF KNAPP #1

TRY 5300 CFS OVER KNAPP #1

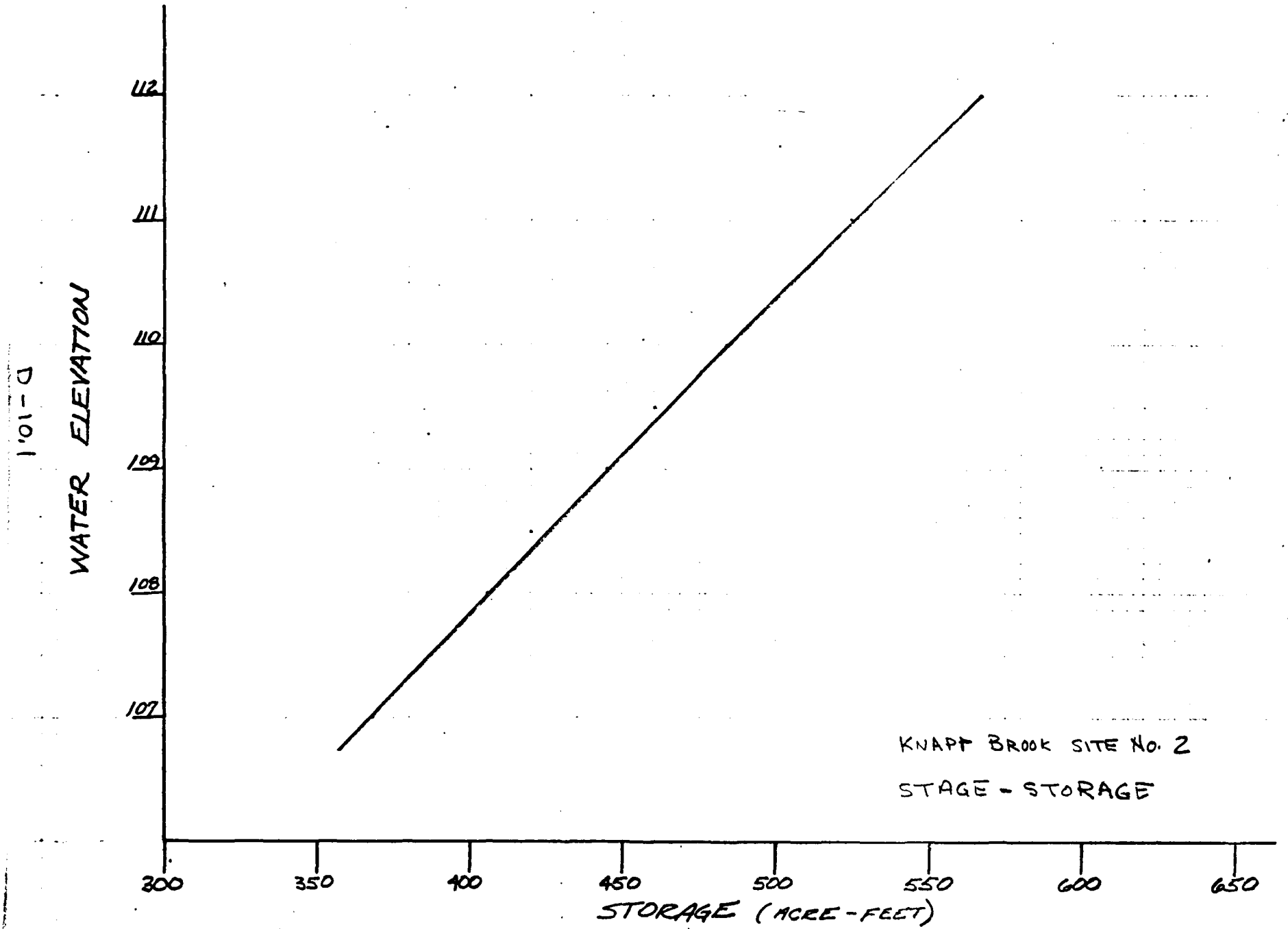
∴ WATER SURFACE ELEVATION = 97.9

FLOOD WAVE ⇒ $Q_p = 8/27\ (.4)(205)\sqrt{g}\ (113.3 - 97.9)^{3/2} = 8330_{cfs}$
KNAPP #1 AVAILABLE STORAGE = 353 − 166 = 187 Ac-Ft
KNAPP #2 STORAGE ABOVE ELEV. 97.9 = 623 − 96 = 527 Ac-Ft

$$Q_{P_2} = 8330 \text{ cfs} \left[1 - \frac{187}{527}\right] \simeq 5375 \text{ cfs} \quad \text{vs} \quad 5300 \text{ cfs}$$

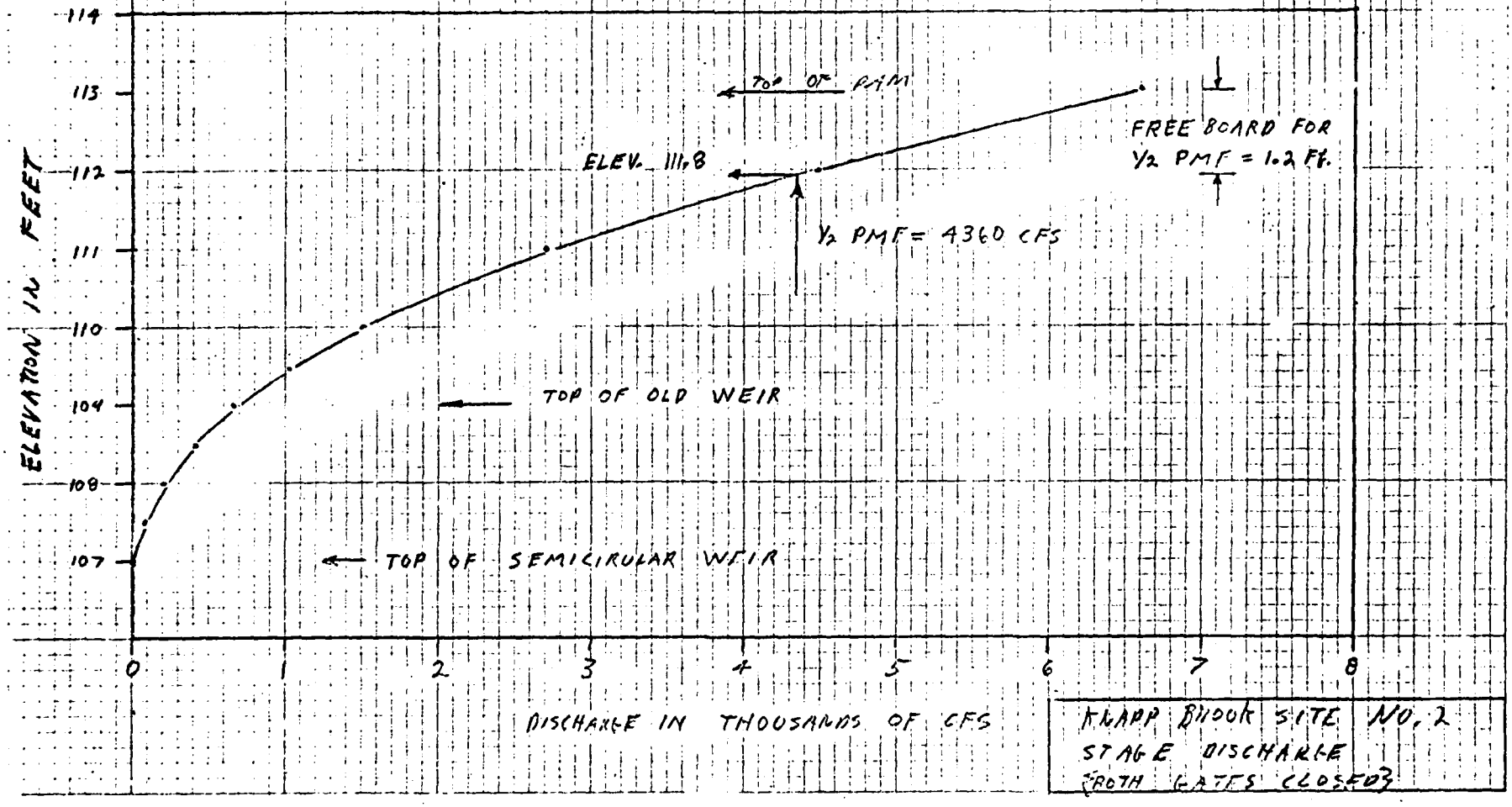
% ERROR ≃ 1%

USING 5340 CFS, 2.1 FEET OVER DAM.


WATER ELEVATION
112
111
110
109
108
107
300
350
400
450
500
550
600
650
STORAGE (ACRE-FEET)
KNAPP BROOK SITE No. 2
STAGE - STORAGE

D-101

FIELD	1	2	3	4	5	6	7	8	9	10
ELEVATION (FT)	107	107.5	108	108.5	109	109.5	110	111	112	113
STORAGE (AC-FT)	368	387	405	420	444	460	483	524	566	610
DISCHARGE (CFS)	0	74	217	420	666	1024	1509	2727	4474	6600



KLAPP BROOK SITE NO. 2
STAGE DISCHARGE
(BOTH GATES CLOSED)

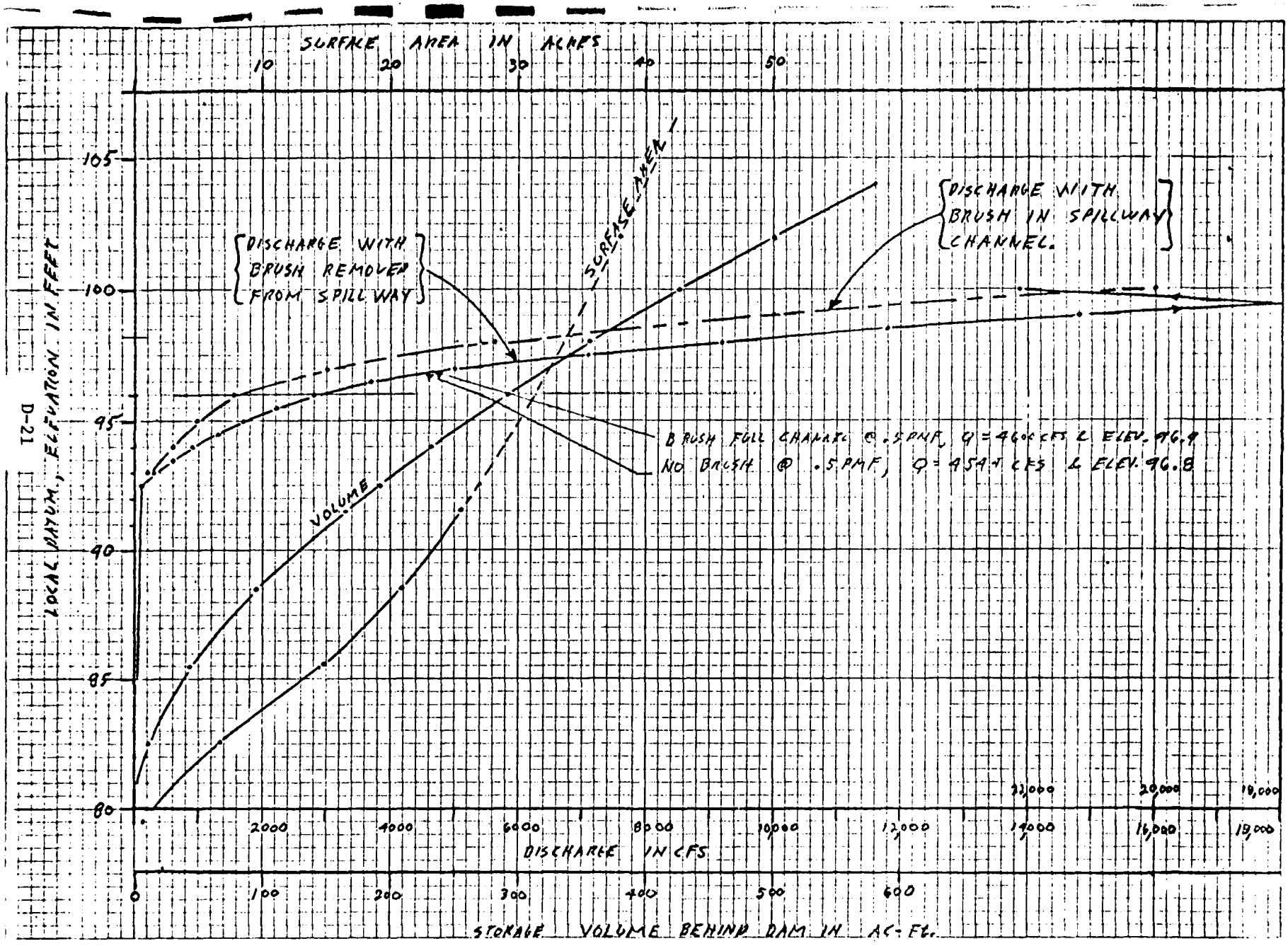
DUFRESNE-HENRY ENGINEERING CORPORATION

BY S.G. EARLS NORTH SUBJECT ATWAPA BROOK SITE NO. 2 SHEET NO. 20 OF
DATE 5-16-79 OPEN FLOW HYDRAULICS JOB NO. 04-0091

$Q = C L_{AVE} H^{3/2}$

ELEVATION (msl)	WEIR #1 (BROAD-CRESTED) H	L	L_{AVE}	C	Q (CFS)	WEIR #2 (BROAD-CREST) H (FT)	L (FT)	L_{AVE} (FT)	C	Q (CFS)	SPILLWAY FROM SHEET #1	TOTAL Q
109.0	0	55	55	2.78	0						666	666
109.5	.5	70	62.5	2.78	61 cfs						963	1024
110.0	1.0	88	71	2.78	197						1312	1509
110.5	1.5	93	76.5	2.78	391						–	–
111.0	2.0	100	81	2.78	637						2090	2727
111.5	2.5	106	85	2.78	934						–	–
112.0	3.0	113	89	2.78	1286						3188	4474
112.5	3.5	120	93	2.78	1693						–	–
113.0	4.0	126	97	2.78	2157						4449	6606
113.3	4.3	130~	98	2.78	2430	0	200	200	2.78	0	4725	7155
113.5	4.5	133	100	2.78	2654	.2	350	275	2.78	68	5152	7874
114.0	5.0	137	104	2.78	3232	.7	380	310	2.78	504	5908	9644
114.5	5.5	140	107	2.79	3851	1.2	385	329	2.78	1203	–	–
115.0	6.0	143	109	2.80	4486	1.7	390	341	2.78	2100	7602	14,188
115.5	6.5	147	112	2.80	5196	2.2	395	350	2.78	3175	8539	16,910

$Q = C L_{AVE} H^{3/2}$ C VALUES FROM KING & BRATER, HANDBOOK OF HYDRAULICS, TABLE 5-5(a), (LEVEL CREST)

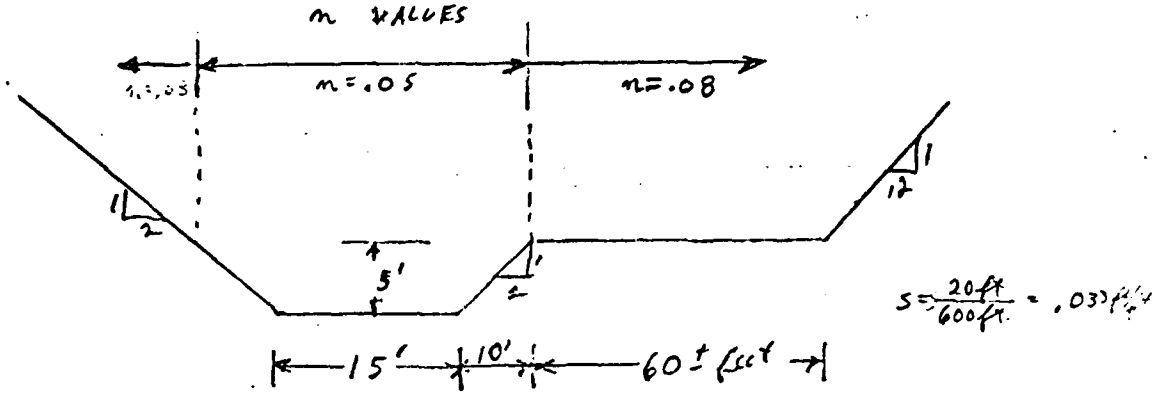


D-21

5-22-70 KNAPP NO. 1 CURVES

DUFRESNE-HENRY ENGINEERING CORPORATION

BY S.C. FARNSWORTH SUBJECT KLAPP BROOK SITE NO. 1 SHEET NO. ____
DATE 5-10-74 FLOOD WAVE BELOW DAM JOB NO. 04-0092

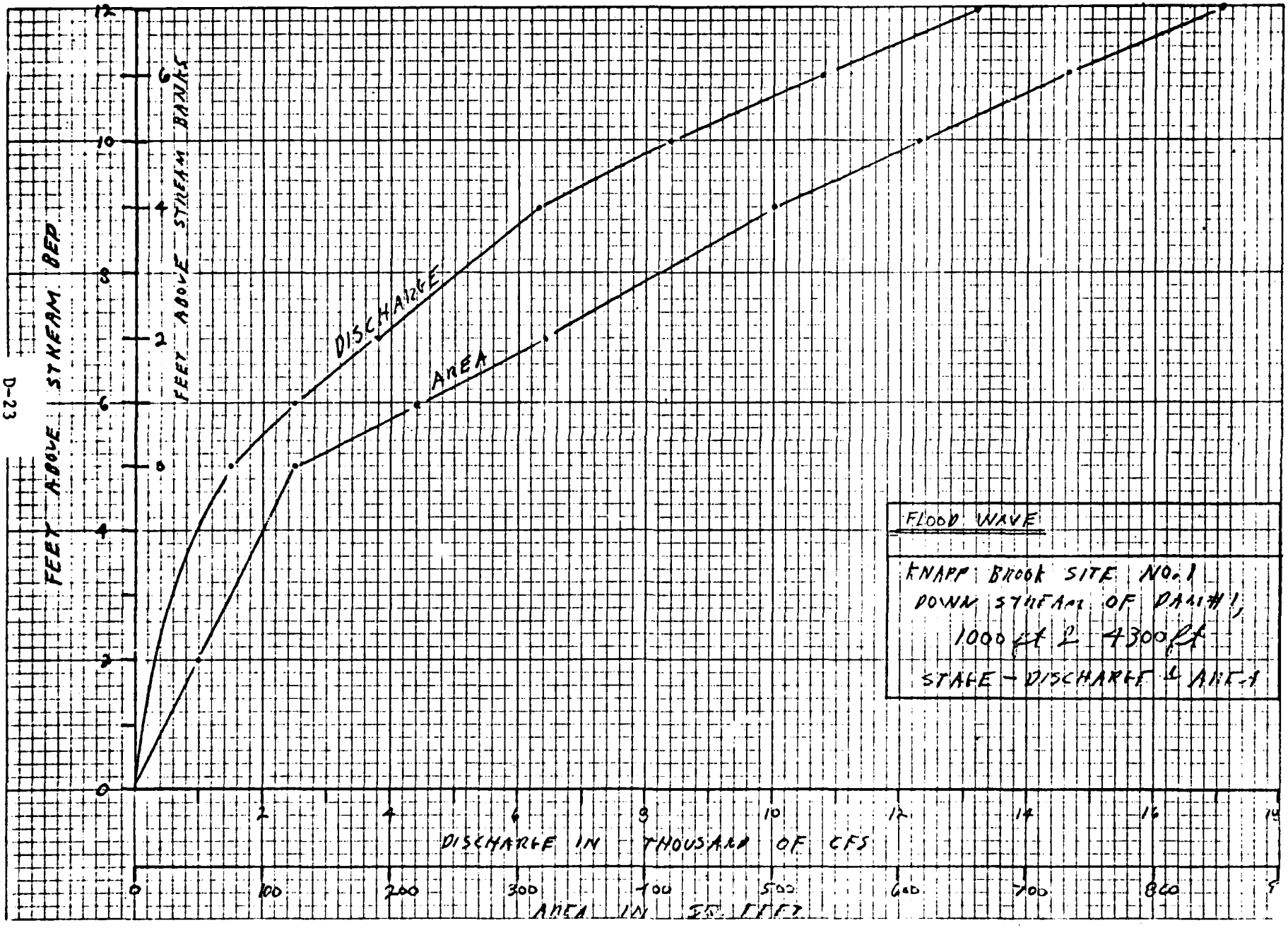


$S = \frac{20 ft}{600 ft} = .033 ft/ft$

DEPTH ABOVE STREAM BED (ft)	n	AREA (S.F.)	WP (ft)	Q (CFS)
5	.05	125	37	1519 CFS
6	.05	160	37	2293
	.08	62	64	204
		222		2497 CFS
7	.05	195	37	3188 CFS
	.08	128	68	654
		323		3842 CFS
9	.05	230	37	4198
	.08	272	78	2110
		502		6308 CFS
10	.05	265	37	5316
	.08	350	82	3108
		615		8424 CFS
11	.05	300	37	6537
	.08	432	87	4243
		732		10,789 CFS
12	.05	335	37	7857
	.08	518	91	5572
		853		13,229 CFS

$Q = \frac{1.486}{n} A R^{2/3} S^{1/2}$

ESTIMATED FLOOD HEIGHT AT FOOT OF DAM 7 feet ABOVE STREAM BANKS, OR 12 feet ABOVE STREAM BED


FEET ABOVE STREAM BED
FEET ABOVE STREAM BANKS
DISCHARGE
AREA
FLOOD WAVE
KNAPP BROOK SITE NO. 1
DOWN STREAM OF DAM #1
1000 ft ℄ 4300 ft
STAGE - DISCHARGE & AREA
DISCHARGE IN THOUSAND OF CFS
AREA IN SQ. FEET

DUFRESNE-HENRY ENGINEERING CORPORATION

BY Morris Root SUBJECT HEC-1 SHEET NO. D-23.1 OF ___
DATE 3-31-80 Data Summary JOB NO. 04-0092

Inflow	D.A.	T_p	I_a	f	PMS
to Knapp No. 2	2.89	1.5	.3	.18	18
between No. 2 & No. 1	0.28	.24	.3	.18	18

PMS Distribution

R_6	R_{12}	R_{24}
111%	123%	133%

Test Flood (0.5 PMF)

Inflow to knapp No. 2	4500 cfs	1560 csm
Routed outflow No. 2	4360 cfs	
Inflow to Knapp No. 1	4600 cfs	1450 csm
Routed outflow No. 1	4570 cfs	

HEC-1 VERSION DATED JAN 1973
UPDATED AUG 74
CHANGE NO. 01

KNAPP POND NO. 1 AND 2
CAVENDISH, VERMONT
TEST FLOOD ROUTING - 0.5 PMF

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
144	0	10	1	0	0	0	2	0	0

JOPER 3 NWT 0

SUB-AREA RUNOFF COMPUTATION

WATERSHED RUN OFF INTO KNAPP POND

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME
1	0	0	0	0	0	1

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	1	2.89	0.0	0.0	1.00	0.500	0	0	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.0	18.00	111.00	123.00	133.00	0.0	0.0	0.0

LOSS DATA

STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0.0	0.0	1.00	0.0	0.0	1.00	0.30	0.18	0.0	0.02

UNIT HYDROGRAPH DATA
TP= 1.50 CP=0.75 NTA= 0

RECESSION DATA
STRTQ= 6.00 QRCSN= -0.10 RTIOR= 1.50

APPROXIMATE CLARK COEFFICIENTS FROM GIVEN SNYDER CP AND TP ARE TC=10.75 AND R= 5.58 INTERVALS

UNIT HYDROGRAPH 36 END-OF-PERIOD ORDINATES, LAG= 1.50 HOURS, CP= 0.75 VOL= 1.00

37.	135.	268.	414.	567.	716.	838.	913.	946.	935.
868.	748.	625.	522.	436.	365.	305.	255.	213.	178.
149.	124.	104.	87.	72.	61.	51.	42.	35.	30.
25.	21.	17.	14.	12.	10.				

END-OF-PERIOD FLOW

	TIME	RAIN	EXCS	COMP Q
1	0 10	0.02	0.00	6.
1	0 20	0.02	0.00	6.
1	0 30	0.02	0.00	6.
1	0 40	0.02	0.00	5.
1	0 50	0.02	0.00	6.
1	0 60	0.02	0.00	6.
1	1 10	0.02	0.00	6.
1	1 20	0.02	0.00	6.
1	1 30	0.02	0.00	6.
1	1 40	0.02	0.00	7.
1	1 50	0.02	0.00	7.
1	1 60	0.02	0.00	7.
1	2 10	0.02	0.00	7.
1	2 20	0.02	0.00	7.
1	2 30	0.02	0.00	7.
1	2 40	0.02	0.00	7.
1	2 50	0.02	0.00	7.
1	2 60	0.02	0.00	7.
1	3 10	0.02	0.00	7.
1	3 20	0.02	0.00	7.
1	3 30	0.02	0.00	7.
1	3 40	0.02	0.00	7.
1	3 50	0.02	0.00	7.
1	3 60	0.02	0.00	7.
1	4 10	0.02	0.00	7.
1	4 20	0.02	0.00	7.
1	4 30	0.02	0.00	7.
1	4 40	0.02	0.00	7.
1	4 50	0.02	0.00	7.
1	4 60	0.02	0.00	7.
1	5 10	0.02	0.00	7.
1	5 20	0.02	0.00	7.
1	5 30	0.02	0.00	6.
1	5 40	0.02	0.00	6.
1	5 50	0.02	0.00	6.
1	5 60	0.02	0.00	6.
1	6 10	0.06	0.03	7.
1	6 20	0.06	0.03	11.
1	6 30	0.06	0.03	19.

1	6	40	0.06	0.03	32.
1	6	50	0.06	0.03	49.
1	6	60	0.06	0.03	71.
1	7	10	0.06	0.03	96.
1	7	20	0.06	0.03	123.
1	7	30	0.06	0.03	152.
1	7	40	0.06	0.03	180.
1	7	50	0.06	0.03	206.
1	7	60	0.06	0.03	229.
1	8	10	0.06	0.03	248.
1	8	20	0.06	0.03	263.
1	8	30	0.06	0.03	277.
1	8	40	0.06	0.03	288.
1	8	50	0.06	0.03	297.
1	8	60	0.06	0.03	304.
1	9	10	0.06	0.03	311.
1	9	20	0.06	0.03	316.
1	9	30	0.06	0.03	321.
1	9	40	0.06	0.03	324.
1	9	50	0.06	0.03	328.
1	9	60	0.06	0.03	330.
1	10	10	0.06	0.03	332.
1	10	20	0.06	0.03	334.
1	10	30	0.06	0.03	336.
1	10	40	0.06	0.03	337.
1	10	50	0.06	0.03	338.
1	10	60	0.06	0.03	339.
1	11	10	0.06	0.03	339.
1	11	20	0.06	0.03	340.
1	11	30	0.06	0.03	341.
1	11	40	0.06	0.03	341.
1	11	50	0.06	0.03	341.
1	11	60	0.06	0.03	342.
1	12	10	0.33	0.30	352.
1	12	20	0.33	0.30	389.
1	12	30	0.33	0.30	462.
1	12	40	0.33	0.30	575.
1	12	50	0.33	0.30	730.
1	12	60	0.33	0.30	925.
1	13	10	0.40	0.37	1156.
1	13	20	0.40	0.37	1415.
1	13	30	0.40	0.37	1691.
1	13	40	0.40	0.37	1973.
1	13	50	0.40	0.37	2248.
1	13	60	0.40	0.37	2499.
1	14	10	0.50	0.47	2729.
1	14	20	0.50	0.47	2946.
1	14	30	0.50	0.47	3155.
1	14	40	0.50	0.47	3358.
1	14	50	0.50	0.47	3556.
1	14	60	0.50	0.47	3747.
1	15	10	1.27	1.24	3958.
1	15	20	1.27	1.24	4236.
1	15	30	1.27	1.24	4606.
1	15	40	1.27	1.24	5075.
1	15	50	1.27	1.24	5644.
1	15	60	1.27	1.24	6308.
1	16	10	0.47	0.44	7016.
1	16	20	0.47	0.44	7688.
1	16	30	0.47	0.44	8266.
1	16	40	0.47	0.44	8707.
1	16	50	0.47	0.44	8964.
1	16	60	0.47	0.44	9004.
1	17	10	0.37	0.34	8842.
1	17	20	0.37	0.34	8526.
1	17	30	0.37	0.34	8100.
1	17	40	0.37	0.34	7610.
1	17	50	0.37	0.34	7111.
1	17	60	0.37	0.34	6650.
1	18	10	0.03	0.00	6226.
1	18	20	0.03	0.00	5816.
1	18	30	0.03	0.00	5402.
1	18	40	0.03	0.00	4979.
1	18	50	0.03	0.00	4542.
1	18	60	0.03	0.00	4093.
1	19	10	0.03	0.00	3636.
1	19	20	0.03	0.00	3183.
1	19	30	0.03	0.00	2763.
1	19	40	0.03	0.00	2327.
1	19	50	0.03	0.00	1951.
1	19	60	0.03	0.00	1628.
1	20	10	0.03	0.00	1358.
1	20	20	0.03	0.00	1132.
1	20	30	0.03	0.00	943.
1	20	40	0.03	0.00	874.
1	20	50	0.03	0.00	840.
1	20	60	0.03	0.00	806.
1	21	10	0.03	0.00	774.
1	21	20	0.03	0.00	743.
1	21	30	0.03	0.00	714.
1	21	40	0.03	0.00	685.
1	21	50	0.03	0.00	658.
1	21	60	0.03	0.00	632.

1 22 10	0.03	0.00	607.
1 22 20	0.03	0.00	583.
1 22 30	0.03	0.00	560.
1 22 40	0.03	0.00	537.
1 22 50	0.03	0.00	516.
1 22 60	0.03	0.00	496.
1 23 10	0.03	0.00	476.
1 23 20	0.03	0.00	457.
1 23 30	0.03	0.00	439.
1 23 40	0.03	0.00	421.
1 23 50	0.03	0.00	405.
1 23 60	0.03	0.00	389.
SUM	24.00	20.04	231868.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	9004.	5375.	1610.	1610.	231865.
INCHES		17.30	20.73	20.73	20.73
AC-FT		2667.	3195.	3195.	3195.

DVN

RUNOFF MULTIPLIED BY 0.50

3.	3.	3.	3.	3.	3.	3.	3.	3.	3.
3.	3.	4.	4.	4.	4.	4.	4.	4.	4.
4.	4.	4.	3.	3.	3.	3.	3.	3.	3.
3.	3.	3.	3.	3.	3.	4.	6.	10.	16.
24.	35.	48.	62.	76.	90.	103.	114.	124.	132.
138.	144.	148.	152.	155.	158.	160.	162.	164.	165.
166.	167.	168.	168.	169.	169.	170.	170.	170.	171.
171.	171.	176.	194.	231.	287.	365.	463.	578.	707.
845.	987.	1124.	1250.	1365.	1473.	1578.	1679.	1778.	1873.
1979.	2118.	2303.	2537.	2822.	3154.	3508.	3844.	4133.	4353.
4482.	4502.	4421.	4263.	4050.	3805.	3555.	3325.	3113.	2908.
2701.	2489.	2271.	2046.	1818.	1592.	1372.	1164.	975.	814.
679.	566.	472.	437.	420.	403.	387.	372.	357.	343.
329.	316.	303.	291.	280.	269.	258.	248.	238.	228.
219.	211.	202.	194.						

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	4502.	2687.	805.	805.	115932.
INCHES		8.65	10.37	10.37	10.37
AC-FT		1333.	1598.	1598.	1598.

•OVN•

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HYDROGRAPH ROUTING

RESERVOIR ROUTING --- KNAPP POND DAM NO. 2 --GATES

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME
1	1	0	0	0	0	1

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME
0.0	0.0	0.0	1	0

NSTPS	NSTOL	LAG	AMSKK	X	TSK	STORA
1	0	0	0.0	0.0	0.0	-1.

STORAGE#	368.	387.	405.	420.	444.	460.	483.	524.	566.	610.
OUTFLOW#	0.	74.	217.	420.	666.	1024.	1509.	2727.	4474.	6600.

	TIME	EOP STOR	AVG IN	EOP OUT
1	0 10	369.	3.	3.
1	0 20	369.	3.	3.
1	0 30	369.	3.	3.
1	0 40	369.	3.	3.
1	0 50	369.	3.	3.
1	0 60	369.	3.	3.
1	1 10	369.	3.	3.
1	1 20	369.	3.	3.
1	1 30	369.	3.	3.
1	1 40	369.	3.	3.
1	1 50	369.	3.	3.
1	1 60	369.	3.	3.
1	2 10	369.	4.	3.
1	2 20	369.	4.	3.
1	2 30	369.	4.	3.
1	2 40	369.	4.	3.
1	2 50	369.	4.	3.
1	2 60	369.	4.	3.
1	3 10	369.	4.	3.
1	3 20	369.	4.	3.
1	3 30	369.	4.	3.
1	3 40	369.	4.	3.
1	3 50	369.	4.	3.
1	3 60	369.	4.	3.
1	4 10	369.	3.	3.
1	4 20	369.	3.	3.
1	4 30	369.	3.	3.
1	4 40	369.	3.	3.
1	4 50	369.	3.	3.
1	4 60	369.	3.	3.
1	5 10	369.	3.	3.
1	5 20	369.	3.	3.
1	5 30	369.	3.	3.
1	5 40	369.	3.	3.
1	5 50	369.	3.	3.
1	5 60	369.	3.	3.
1	6 10	369.	3.	3.
1	6 20	369.	5.	3.
1	6 30	369.	8.	4.
1	6 40	369.	13.	4.
1	6 50	369.	20.	5.
1	6 60	370.	30.	6.
1	7 10	370.	42.	8.
1	7 20	371.	55.	11.
1	7 30	371.	69.	14.
1	7 40	372.	83.	17.
1	7 50	373.	97.	21.
1	7 60	375.	109.	26.
1	8 10	376.	119.	31.
1	8 20	377.	128.	36.
1	8 30	379.	135.	41.
1	8 40	380.	141.	46.
1	8 50	381.	146.	51.
1	8 60	383.	150.	57.
1	9 10	384.	154.	62.
1	9 20	385.	157.	67.
1	9 30	386.	159.	72.
1	9 40	388.	161.	78.
1	9 50	389.	163.	87.
1	9 60	390.	164.	95.
1	10 10	391.	166.	102.
1	10 20	391.	167.	109.
1	10 30	392.	167.	115.
1	10 40	393.	168.	121.

1 10 50	393.	169.	128.
1 10 60	394.	169.	130.
1 11 10	395.	170.	134.
1 11 20	395.	170.	138.
1 11 30	395.	170.	141.
1 11 40	396.	170.	144.
1 11 50	396.	171.	147.
1 11 60	397.	171.	149.
1 12 10	397.	173.	152.
1 12 20	397.	185.	155.
1 12 30	398.	213.	161.
1 12 40	399.	259.	171.
1 12 50	401.	326.	188.
1 12 60	404.	414.	211.
1 13 10	408.	520.	260.
1 13 20	413.	643.	325.
1 13 30	419.	776.	402.
1 13 40	425.	916.	474.
1 13 50	433.	1055.	551.
1 13 60	441.	1187.	634.
1 14 10	449.	1307.	782.
1 14 20	457.	1419.	952.
1 14 30	464.	1525.	1101.
1 14 40	470.	1628.	1235.
1 14 50	476.	1729.	1360.
1 14 60	482.	1826.	1478.
1 15 10	487.	1926.	1620.
1 15 20	492.	2049.	1766.
1 15 30	497.	2210.	1917.
1 15 40	502.	2420.	2088.
1 15 50	509.	2680.	2289.
1 15 60	517.	2988.	2526.
1 16 10	526.	3331.	2822.
1 16 20	535.	3676.	3203.
1 16 30	544.	3989.	3553.
1 16 40	551.	4243.	3860.
1 16 50	557.	4418.	4108.
1 16 60	561.	4492.	4279.
1 17 10	563.	4461.	4360.
1 17 20	563.	4342.	4352.
1 17 30	561.	4156.	4265.
1 17 40	557.	3928.	4115.
1 17 50	553.	3680.	3921.
1 17 60	548.	3440.	3707.
1 18 10	542.	3219.	3490.
1 18 20	537.	3010.	3276.
1 18 30	532.	2805.	3066.
1 18 40	527.	2595.	2856.
1 18 50	522.	2380.	2664.
1 18 60	516.	2159.	2492.
1 19 10	510.	1932.	2302.
1 19 20	503.	1705.	2099.
1 19 30	496.	1482.	1889.
1 19 40	489.	1268.	1678.
1 19 50	482.	1070.	1481.
1 19 60	475.	895.	1332.
1 20 10	468.	747.	1184.
1 20 20	461.	622.	1041.
1 20 30	455.	519.	903.
1 20 40	449.	454.	783.
1 20 50	445.	428.	688.
1 20 60	442.	411.	641.
1 21 10	438.	395.	608.
1 21 20	435.	379.	578.
1 21 30	433.	364.	550.
1 21 40	430.	350.	523.
1 21 50	428.	336.	499.
1 21 60	425.	323.	475.
1 22 10	423.	310.	454.
1 22 20	421.	297.	433.
1 22 30	419.	286.	412.
1 22 40	418.	274.	388.
1 22 50	416.	263.	367.
1 22 60	415.	253.	348.
1 23 10	413.	243.	330.
1 23 20	412.	233.	313.
1 23 30	411.	224.	298.
1 23 40	410.	215.	284.
1 23 50	409.	207.	271.
1 23 60	408.	198.	258.
SUM			113110.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	4360.	2633.	785.	785.	113110.
INCHES		8.47	10.11	10.11	10.11
AC-FT		1306.	1559.	1559.	1559.

SUB-AREA RUNOFF COMPUTATION

SUB-AREA NO. 2 TO KNAPP 1

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME
2	0	0	0	0	0	1

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	1	0.30	0.0	0.0	1.00	0.500	0	0	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.0	18.00	111.00	123.00	133.00	0.0	0.0	0.0

LOSS DATA

STRKR	DLTKR	PTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0.0	0.0	1.00	0.0	0.0	1.00	0.30	0.18	0.0	0.15

UNIT HYDROGRAPH DATA

TP# 0.24 CP#0.75 NTA# 0

RECESSION DATA

STRTQ# 1.00 QRCSN# -0.10 RTIOR# 1.50

APPROXIMATE CLARK COEFFICIENTS FROM GIVEN SNYDER CP AND TP ARE TC# 1.98 AND R# 0.65 INTERVALS

UNIT HYDROGRAPH 5 END-OF-PERIOD ORDINATES, LAG# 0.24 HOURS, CP# 0.75 VOL# 1.00

255. 537. 320. 43. 6.

END-OF-PERIOD FLOW

	TIME	RAIN	EXCS	COMP Q
1	0 10	0.02	0.00	2.
1	0 20	0.02	0.00	3.
1	0 30	0.02	0.00	4.
1	0 40	0.02	0.00	4.
1	0 50	0.02	0.00	4.
1	0 60	0.02	0.00	4.
1	1 10	0.02	0.00	4.
1	1 20	0.02	0.00	4.
1	1 30	0.02	0.00	4.
1	1 40	0.02	0.00	4.
1	1 50	0.02	0.00	4.
1	1 60	0.02	0.00	4.
1	2 10	0.02	0.00	4.
1	2 20	0.02	0.00	4.
1	2 30	0.02	0.00	4.
1	2 40	0.02	0.00	4.
1	2 50	0.02	0.00	4.
1	2 60	0.02	0.00	4.
1	3 10	0.02	0.00	4.
1	3 20	0.02	0.00	4.
1	3 30	0.02	0.00	4.
1	3 40	0.02	0.00	4.
1	3 50	0.02	0.00	4.
1	3 60	0.02	0.00	4.
1	4 10	0.02	0.00	4.
1	4 20	0.02	0.00	4.
1	4 30	0.02	0.00	4.
1	4 40	0.02	0.00	4.
1	4 50	0.02	0.00	4.
1	4 60	0.02	0.00	4.
1	5 10	0.02	0.00	4.
1	5 20	0.02	0.00	4.
1	5 30	0.02	0.00	4.
1	5 40	0.02	0.00	4.
1	5 50	0.02	0.00	4.
1	5 60	0.02	0.00	4.
1	6 10	0.06	0.03	12.
1	6 20	0.06	0.03	29.
1	6 30	0.06	0.03	39.
1	6 40	0.06	0.03	40.
1	6 50	0.06	0.03	40.
1	6 60	0.06	0.03	40.
1	7 10	0.06	0.03	40.
1	7 20	0.06	0.03	40.
1	7 30	0.06	0.03	40.
1	7 40	0.06	0.03	40.
1	7 50	0.06	0.03	40.
1	7 60	0.06	0.03	40.
1	8 10	0.06	0.03	40.
1	8 20	0.06	0.03	40.
1	8 30	0.06	0.03	40.
1	8 40	0.06	0.03	40.
1	8 50	0.06	0.03	40.
1	8 60	0.06	0.03	40.
1	9 10	0.06	0.03	40.
1	9 20	0.06	0.03	40.
1	9 30	0.06	0.03	40.
1	9 40	0.06	0.03	40.
1	9 50	0.06	0.03	40.

1	9	60	0.06	0.03	40.
1	10	10	0.06	0.03	40.
1	10	20	0.06	0.03	40.
1	10	30	0.06	0.03	40.
1	10	40	0.06	0.03	40.
1	10	50	0.06	0.03	40.
1	10	60	0.06	0.03	40.
1	11	10	0.06	0.03	40.
1	11	20	0.06	0.03	40.
1	11	30	0.06	0.03	40.
1	11	40	0.06	0.03	40.
1	11	50	0.06	0.03	40.
1	11	60	0.06	0.03	40.
1	12	10	0.33	0.31	110.
1	12	20	0.33	0.31	256.
1	12	30	0.33	0.31	343.
1	12	40	0.33	0.31	355.
1	12	50	0.33	0.31	357.
1	12	60	0.33	0.31	357.
1	13	10	0.40	0.37	374.
1	13	20	0.40	0.37	409.
1	13	30	0.40	0.37	431.
1	13	40	0.40	0.37	434.
1	13	50	0.40	0.37	434.
1	13	60	0.40	0.37	434.
1	14	10	0.50	0.47	459.
1	14	20	0.50	0.47	513.
1	14	30	0.50	0.47	545.
1	14	40	0.50	0.47	549.
1	14	50	0.50	0.47	550.
1	14	60	0.50	0.47	550.
1	15	10	1.27	1.24	745.
1	15	20	1.27	1.24	1156.
1	15	30	1.27	1.24	1401.
1	15	40	1.27	1.24	1434.
1	15	50	1.27	1.24	1438.
1	15	60	1.27	1.24	1438.
1	16	10	0.47	0.44	1235.
1	16	20	0.47	0.44	806.
1	16	30	0.47	0.44	550.
1	16	40	0.47	0.44	516.
1	16	50	0.47	0.44	511.
1	16	60	0.47	0.44	511.
1	17	10	0.37	0.34	486.
1	17	20	0.37	0.34	432.
1	17	30	0.37	0.34	400.
1	17	40	0.37	0.34	396.
1	17	50	0.37	0.34	395.
1	17	60	0.37	0.34	395.
1	18	10	0.03	0.00	310.
1	18	20	0.03	0.00	143.
1	18	30	0.03	0.00	138.
1	18	40	0.03	0.00	132.
1	18	50	0.03	0.00	127.
1	18	60	0.03	0.00	122.
1	19	10	0.03	0.00	117.
1	19	20	0.03	0.00	112.
1	19	30	0.03	0.00	108.
1	19	40	0.03	0.00	104.
1	19	50	0.03	0.00	100.
1	19	60	0.03	0.00	96.
1	20	10	0.03	0.00	92.
1	20	20	0.03	0.00	88.
1	20	30	0.03	0.00	85.
1	20	40	0.03	0.00	81.
1	20	50	0.03	0.00	78.
1	20	60	0.03	0.00	75.
1	21	10	0.03	0.00	72.
1	21	20	0.03	0.00	69.
1	21	30	0.03	0.00	66.
1	21	40	0.03	0.00	64.
1	21	50	0.03	0.00	61.
1	21	60	0.03	0.00	59.
1	22	10	0.03	0.00	56.
1	22	20	0.03	0.00	54.
1	22	30	0.03	0.00	52.
1	22	40	0.03	0.00	50.
1	22	50	0.03	0.00	48.
1	22	60	0.03	0.00	46.
1	23	10	0.03	0.00	44.
1	23	20	0.03	0.00	42.
1	23	30	0.03	0.00	41.
1	23	40	0.03	0.00	39.
1	23	50	0.03	0.00	38.
1	23	60	0.03	0.00	36.
		SUM	24.00	20.10	26291.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1438.	609.	183.	183.	26296.
INCHES		18.87	22.65	22.65	22.65
AC-FT		302.	362.	362.	362.

DVN

********** ********** ********** ********** **********

COMBINE HYDROGRAPHS

COMBINING FLOW KNAPP 1 AND 2

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME
20	2	0	0	0	0	1

SUM OF 2 HYDROGRAPHS AT 20

4.	5.	5.	5.	5.	5.	5.	5.	5.	5.
5.	5.	5.	5.	5.	5.	5.	5.	5.	5.
5.	5.	5.	5.	5.	5.	5.	5.	5.	5.
5.	5.	5.	5.	5.	5.	9.	18.	23.	24.
25.	26.	28.	31.	34.	37.	41.	46.	51.	56.
61.	66.	72.	77.	82.	87.	92.	98.	107.	115.
123.	129.	135.	141.	146.	150.	154.	158.	161.	164.
167.	170.	207.	283.	333.	349.	366.	389.	447.	530.
617.	691.	768.	851.	1012.	1209.	1374.	1509.	1635.	1753.
1992.	2344.	2617.	2805.	3008.	3245.	3440.	3606.	3828.	4118.
4364.	4535.	4603.	4548.	4465.	4313.	4119.	3905.	3644.	3348.
3135.	2923.	2727.	2553.	2361.	2155.	1943.	1730.	1531.	1380.
1230.	1085.	965.	824.	727.	678.	644.	613.	583.	555.
529.	505.	482.	460.	438.	413.	391.	371.	352.	334.
318.	303.	289.	276.						

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	4603.	2889.	877.	877.	12625d.
INCHES		8.43	10.23	10.23	10.23
AC-FT		1433.	1740.	1740.	1740.

HYDROGRAPH ROUTING

RESERVOIR ROUTING --- KNAPP POND DAM NO 1 W/BRUSH

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME
3	1	0	0	0	0	1

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME
0.0	0.0	0.0	1	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA
1	0	0	0.0	0.0	0.0	-1.

STORAGE	192.	205.	231.	260.	292.	325.	357.	391.	427.	0.
OUTFLOW	118.	236.	589.	989.	1549.	3011.	5669.	10081.	15933.	0.

	TIME	EOP STOR	AVG IN	EOP OUT
1	0 10	193.	4.	4.
1	0 20	192.	4.	118.
1	0 30	191.	5.	105.
1	0 40	189.	5.	93.
1	0 50	188.	5.	83.
1	0 60	187.	5.	73.
1	1 10	186.	5.	65.
1	1 20	185.	5.	58.
1	1 30	185.	5.	52.
1	1 40	184.	5.	47.
1	1 50	184.	5.	42.
1	1 60	183.	5.	37.
1	2 10	183.	5.	34.
1	2 20	182.	5.	30.
1	2 30	182.	5.	27.
1	2 40	182.	5.	25.
1	2 50	181.	5.	22.
1	2 60	181.	5.	20.
1	3 10	181.	5.	18.
1	3 20	181.	5.	17.
1	3 30	181.	5.	16.
1	3 40	181.	5.	14.
1	3 50	180.	5.	13.
1	3 60	180.	5.	12.
1	4 10	180.	5.	11.
1	4 20	180.	5.	11.
1	4 30	180.	5.	10.
1	4 40	180.	5.	9.
1	4 50	180.	5.	9.
1	4 60	180.	5.	9.
1	5 10	180.	5.	8.
1	5 20	180.	5.	8.
1	5 30	180.	5.	7.
1	5 40	180.	5.	7.
1	5 50	180.	5.	7.
1	5 60	180.	5.	7.
1	6 10	180.	7.	7.
1	6 20	180.	13.	8.
1	6 30	180.	20.	9.
1	6 40	180.	24.	11.
1	6 50	180.	25.	12.
1	6 60	181.	26.	14.
1	7 10	181.	27.	16.
1	7 20	181.	29.	17.
1	7 30	181.	32.	19.
1	7 40	181.	35.	21.
1	7 50	182.	39.	23.
1	7 60	182.	44.	25.
1	8 10	182.	48.	28.
1	8 20	182.	53.	31.
1	8 30	183.	59.	34.
1	8 40	183.	64.	38.
1	8 50	184.	69.	41.
1	8 60	184.	74.	45.
1	9 10	184.	79.	49.
1	9 20	185.	84.	53.
1	9 30	185.	89.	58.
1	9 40	186.	95.	62.
1	9 50	186.	103.	67.
1	9 60	187.	111.	72.
1	10 10	188.	119.	78.
1	10 20	188.	126.	83.
1	10 30	189.	132.	89.
1	10 40	189.	138.	95.
1	10 50	190.	143.	100.
1	10 60	191.	148.	106.
1	11 10	191.	152.	111.
1	11 20	192.	156.	117.
1	11 30	192.	160.	122.
1	11 40	193.	163.	127.
1	11 50	193.	166.	131.
1	11 60	194.	168.	136.
1	12 10	195.	188.	142.
1	12 20	196.	245.	154.
1	12 30	198.	308.	172.
1	12 40	200.	341.	192.

1	12 50	202.	357.	211.
1	12 60	204.	378.	231.
1	13 10	207.	418.	261.
1	13 20	210.	489.	300.
1	13 30	213.	574.	347.
1	13 40	217.	654.	399.
1	13 50	221.	729.	456.
1	13 60	226.	810.	516.
1	14 10	231.	932.	587.
1	14 20	237.	1110.	678.
1	14 30	245.	1291.	784.
1	14 40	253.	1441.	898.
1	14 50	262.	1572.	1021.
1	14 60	270.	1694.	1166.
1	15 10	279.	1873.	1318.
1	15 20	289.	2168.	1501.
1	15 30	300.	2480.	1903.
1	15 40	309.	2711.	2281.
1	15 50	315.	2906.	2573.
1	15 60	321.	3127.	2832.
1	16 10	326.	3343.	3104.
1	16 20	330.	3523.	3409.
1	16 30	332.	3717.	3633.
1	16 40	335.	3973.	3880.
1	16 50	339.	4241.	4143.
1	16 60	341.	4449.	4366.
1	17 10	343.	4569.	4514.
1	17 20	344.	4586.	4566.
1	17 30	343.	4517.	4530.
1	17 40	342.	4389.	4427.
1	17 50	340.	4216.	4273.
1	17 60	338.	4012.	4083.
1	18 10	335.	3775.	3859.
1	18 20	332.	3496.	3595.
1	18 30	329.	3241.	3338.
1	18 40	326.	3029.	3113.
1	18 50	323.	2825.	2942.
1	18 60	320.	2640.	2801.
1	19 10	317.	2457.	2640.
1	19 20	313.	2258.	2461.
1	19 30	308.	2049.	2269.
1	19 40	304.	1837.	2067.
1	19 50	299.	1630.	1863.
1	19 60	295.	1455.	1672.
1	20 10	291.	1305.	1527.
1	20 20	286.	1158.	1447.
1	20 30	281.	1015.	1354.
1	20 40	275.	884.	1253.
1	20 50	269.	776.	1150.
1	20 60	264.	703.	1054.
1	21 10	259.	661.	973.
1	21 20	255.	628.	913.
1	21 30	251.	598.	859.
1	21 40	247.	569.	808.
1	21 50	244.	542.	762.
1	21 60	240.	517.	720.
1	22 10	238.	493.	680.
1	22 20	235.	471.	644.
1	22 30	233.	449.	610.
1	22 40	230.	425.	578.
1	22 50	228.	402.	548.
1	22 60	226.	381.	520.
1	23 10	224.	361.	492.
1	23 20	222.	343.	467.
1	23 30	220.	326.	443.
1	23 40	219.	311.	420.
1	23 50	217.	296.	399.
1	23 60	216.	283.	379.
	SUM			124656.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	4566.	2829.	866.	866.	124656.
INCHES		8.25	10.10	10.10	10.10
AC-FT		1404.	1718.	1718.	1718.

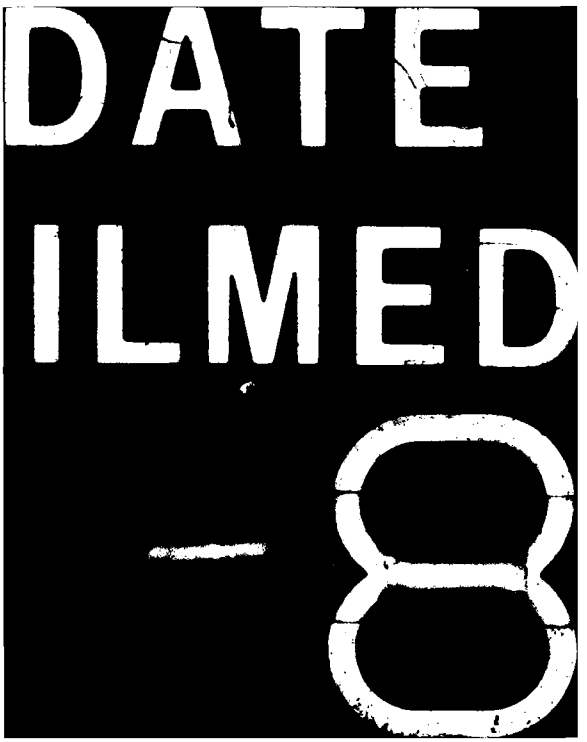
RUNOFF SUMMARY, AVERAGE FLOW

		PEAK	6-HOUR	24-HOUR	72-HOUR	AREA
HYDROGRAPH AT	1	4502.	2687.	805.	805.	2.89
ROUTED TO	1	4360.	2633.	785.	785.	2.89
HYDROGRAPH AT	2	719.	304.	91.	91.	0.30
2 COMBINED	20	4603.	2889.	877.	877.	3.19
ROUTED TO	3	4566.	2829.	866.	866.	3.19

APPENDIX E

Information as Contained in the National Inventory of Dams

NOT AVAILABLE AT THIS TIME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